Society

FOR THE

Promotion of Engineering Education.

PROCEEDINGS

OF THE

NINTH ANNUAL MEETING,

HELD IN

BUFFALO, N. Y., JUNE 29 – JULY 2, 1901.

Volume IX.

EDITED BY

FRANK O. MARVIN, ROBERT FLETCHER, HENRY S. JACOBY,

Committee.

New York,
ENGINEERING NEWS PUBLISHING CO.,
220 Broadway.
1901.

PRESS OF
THE NEW ERA PRINTING COMPANY,
LANCASTER, PA.

TABLE OF CONTENTS.—VOL. IX.

OFFICERS

OF THE

Society for the Promotion of Engineering Education.

1901-1902.

PRESIDENT:

ROBERT FLETCHER, Thayer School of Civil Engineering.

VICE-PRESIDENTS:

STORM BULL, University of Wisconsin.
CALVIN M. WOODWARD, Washington University.

SECRETARY:

HENRY S. JACOBY, Cornell University, Ithaca, N. Y.

TREASURER:

CLARENCE A. WALDO, Purdue University, Lafayette, Ind.

STANDING COMMITTEES.

On Entrance Requirements for Engineering Colleges:

HARRY W. TYLER, *Chairman.*
J. J. FLATHER, *Secretary*, J. P. JACKSON, T. C. MENDENHALL, MANSFIELD MERRIMAN, C. D. MARX, F. W. MCNAIR, F. O. MARVIN, J. C. NAGLE, R. B. OWENS, W. D. PENCE.

On Statistics of Engineering Education:

W. T. MAGRUDER, *Chairman*, L. E. REBER, A. N. TALBOT, H. W. TYLER, The President and the Secretary.

COMMITTEE ON INDUSTRIAL EDUCATION:

J. B. JOHNSON, *Chairman*, H. T. EDDY, EDGAR MARBURG, G. F. SWAIN, R. H. THURSTON, C. M. WOODWARD.

COMMITTEE ON TECHNICAL BOOKS FOR LIBRARIES:

C. F. BURGESS, *Chairman*, H. W. SPANGLER, W. T. SEDGWICK, N. C. RICKER, C. B. DUDLEY, C. F. ALLEN, N. W. LORD.

COUNCIL.*

Terms of Office Expire in 1902.

BROWN AYRES, Tulane University,
GEORGE W. BISSELL, Iowa Agricultural College,
JOHN J. FLATHER, University of Minnesota,
WILLIAM T. MAGRUDER, Ohio State University,
FREDERICK W. McNAIR, Michigan College of Mines,
J. MADISON PORTER, Lafayette College,
A. J. WOOD, Worcester Polytechnic Institute.

Terms of Office Expire in 1903.

C. FRANK ALLEN, Massachusetts Institute of Technology,
JOHN P. BROOKS, State College of Kentucky,
DUGALD C. JACKSON, University of Wisconsin,
EDGAR MARBURG, University of Pennsylvania,
JAMES C. NAGLE, Agricultural and Mechanical College of Texas,
N. CLIFFORD RICKER, University of Illinois,
ARTHUR L. WILLISTON, Pratt Institute.

Terms of Office Expire in 1904.

WILLIAM F. M. GOSS, Purdue University,
THOMAS GRAY, Rose Polytechnic Institute,
DAVID C. HUMPHREYS, Washington and Lee University,
OLIN H. LANDRETH, Union College,
WILLIAM G. RAYMOND, Rensselaer Polytechnic Institute,
LOUIS E. REBER, Pennsylvania State College,
LINGAN S. RANDOLPH, Virginia Polytechnic Institute.

*This list gives only the elective members. The officers (p. v) and the past presidents (p. xxv) are members of the Council *ex officiis*.

List of Members.

Name and Address.	Title.	Date of Membership.
Adams, Comfort A., Jr... Cambridge, Mass	Assistant Professor of Electrical Engineering, Harvard University......	1894
Alderson, Victor C....... Chicago, Ill.	Acting President, Dean of the Technical College, Armour Institute of Technology	1900
Aldrich, William S...... Potsdam, N. Y.	Director, Clarkson School of Technology	1893
Allen, C. Frank......... Boston, Mass.	Professor of Railroad Engineering, Massachusetts Institute of Technology	1893
Anderson, F. Paul....... Lexington, Ky.	Dean of the School of Mechanical and Electrical Engineering, Professor of Mechanical Engineering, Kentucky Agricultural and Mechanical College.	1894
Anderson, Douglas S.... New Orleans, La.	Associate Professor of Electrical Engineering, Tulane University.........	1900
Anthony, Gardner C..... Tufts College, Mass.	Professor of Technical Drawing, Tufts College......................	1896
Arnold, Bion J........... Chicago, Ill.	Consulting Electrical Engineer, 1541 Marquette Bldg..............	1896
Ayer, Arthur W......... Burlington, Vt.	Professor of Mechanical Engineering, University of Vermont............	1894
Ayers, Brown............ New Orleans, La.	Professor of Physics and Electrical Engineering, Dean of College of Technology, Tulane University......	1898
Baker, Ira O............. Champaign, Ill.	Professor of Civil Engineering, University of Illinois..............	1893
Barney, Samuel E., Jr... New Haven, Conn.	Assistant Professor of Civil Engineering, Yale University..............	1894
Barraclough, S. Henry.. Sydney, N. S. W., Australia.	Acting Professor of Engineering, Russell School of Engineering, University of Sydney..............	1900

Name and Address.	Title.	Date of Membership.
Bending, Edward A. Dayton, Ohio.	Principal of Dayton Manual Training School	1899
Benjamin, Charles H. Cleveland, Ohio.	Professor of Mechanical Engineering, Case School of Applied Science	1893
Berg, Walter G. 261 West 52d St. New York City.	Chief Engineer, Lehigh Valley Railroad Co.	1901
Beyer, Samuel W. Ames, Iowa.	Professor of Geology and Mining Engineering, Iowa State Agricultural College	1899
Beyer, T. Raymond 119 Maplewood Ave., Germantown, Pa.	Civil Engineer	1895
Bissell, George W. Ames, Iowa.	Professor of Mechanical Engineering, Iowa State Agricultural College	1894
Bixby, Wm. H. Cincinnati, Ohio.	Major Corps of Engineers, U. S. Army, U. S. Engineer Office	1898
Bohannan, Rosser D. Columbus, Ohio.	Professor of Mathematics, Ohio State University	1899
Bovey, Henry T. Montreal, Que.	Dean of the Faculty of Applied Science, Professor of Civil Engineering and Applied Mechanics, McGill University	1893
Bradford, Joseph N. Columbus, Ohio.	Professor of Architecture and Drawing, Ohio State University	1896
Brady, Frank W. Mesilla Park, New Mexico.	Professor of Engineering, College of Agriculture and the Mechanic Arts	1899
Bray, Charles D. Tufts College, Mass.	Professor of Civil and Mechanical Engineering, Tufts College	1894
Breckenridge, Lester P. Urbana, Ill.	Professor of Mechanical Engineering, University of Illinois	1893
Brill, George M. 1143–1144 Marquette B'lding, Chicago, Ill.	Consulting Engineer	1894
Brooks, John P. Lexington, Ky.	Professor of Civil Engineering, State College of Kentucky	1898

Name and Address.	Title.	Date of Membership.
Brooks, Morgan, Urbana, Ill.	Professor of Electrical Engineering, University of Illinois	1899
Browne, Wm. H., Jr., Urbana, Ill.	Assistant Professor of Electrical Engineering, University of Illinois	1899
Bruegel, Adolph T., Philadelphia, Pa.	With William Cramp and Sons	1900
Bull, Storm, Madison, Wis.	Professor of Steam Engineering, University of Wisconsin	1893
Burgess, Charles F., Madison, Wis.	Assistant Professor of Electrical Engineering, University of Wisconsin	1896
Burnham, Edward C., Providence, R. I.	Associate Professor of Mechanical Engineering, Brown University	1899
Burr, William H., New York, N. Y.	Professor of Civil Engineering, Columbia University	1893
Burrage, Severance, Lafayette, Ind.	Instructor in Sanitary Science, Purdue University	1898
Caldwell, Francis C., Columbus, Ohio.	Professor of Electrical Engineering, Ohio State University	1897
Carpenter, Louis G., Fort Collins, Colo.	Professor of Civil and Irrigation Engineering, Director of Experiment Station, Colorado State Agricultural College	1895
Carpenter, Rolla C., Ithaca, N. Y.	Professor of Experimental Engineering, Cornell University	1893
Carson, William W., Knoxville, Tenn.	Professor of Civil Engineering, University of Tennessee	1894
Chase, Charles H., 37 Lincoln St., Stoneham, Mass.	Instructor in Manual Arts, Tufts College	1900
Chatburn, George R., Lincoln, Neb.	Adjunct Professor of Civil Engineering, University of Nebraska	1899
Chauvenet, Regis, Golden, Colo.	President, State School of Mines of Colorado	1896
Christy, Samuel B., Berkeley, Cal.	Professor of Mining and Metallurgy, University of California	1893

Name and Address.	Title.	Date of Membership.
Colburn, George L. Rochester, N. Y.	Instructor in Machine Work and Mechanical Drawing, Rochester Athaneum and Mechanics Institute	1901
Constant, Frank H. Minneapolis, Minn.	Professor of Structural Engineering, University of Minnesota	1896
Cooley, Mortimer E. Ann Arbor, Mich.	Professor of Mechanical Engineering, University of Michigan	1893
Corthell, Elmer L. care of C. Eddy Hall & Cia, 399 Reconguista, Buenos Aires, Argentine Republic, S. A.	Civil Engineer	1895
Crafts, James M. Boston, Mass.	Professor of Chemistry, Massachusetts Institute of Technology	1898
Crandall, Charles L. Ithaca, N. Y.	Professor of Railroad Engineering and Geodesy, Cornell University	1893
Creighton, W. H. P. New Orleans, La.	Professor of Mechanical Engineering, Tulane University	1893
Crenshaw, Bolling H. Auburn, Ala.	Associate Professor of Mathematics and Mechanical Engineering, Alabama Polytechnic Institute	1894
Cross, Charles R. Boston, Mass.	Professor of Physics, Massachusetts Institute of Technology	1895
Cruikshank, Barton San Francisco, Cal.	President, Cogswell Polytechnic College	1899
Dean, Arthur D. Springfield, Mass.	First Assistant, Mechanic Arts High School	1901
Denison, Charles S. Ann Arbor, Mich.	Professor of Descriptive Geometry, Stereotomy and Drawing, University of Michigan	1893
Denton, James E. Hoboken, N. J.	Professor of Mechanical Engineering and Shopwork, Stevens Institute of Technology	1893
Denton, Frederick W. Houghton, Mich.	Superintendent, Winona Mine	1894
Drown, Thomas M. South Bethlehem, Pa.	President, Lehigh University	1895

Name and Address.	Title.	Date of Membership.
Du Bois, A. Jay.......... New Haven, Conn.	Professor of Civil Engineering, Yale University..................	1894
Dudley, Charles B....... Altoona, Pa.	Chemist, Pennsylvania Railroad Company....	1894
Duncan, Lindsey.......... Schenectady, N. Y.	Instructor in Civil Engineering, Union College....................	1901
Durand, William F........ Ithaca, N. Y.	Professor of Marine Engineering, Cornell University................	1899
Eddy, Henry T........... Minneapolis, Minn.	Professor of Engineering and Mechanics, University of Minnesota........	1893
Emory, Frederick L...... Morgantown, W. Va.	Professor of Mechanics and Applied Mathematics, West Virginia University	1894
Engler, Edmund A........ Worcester, Mass.	President, Worcester Polytechnic Institute	1897
Esty, William........... South Bethlehem, Pa.	Assistant Professor of Electrical Engineering, Lehigh University.......	1898
Faig, John T............. Lexington, Ky.	Assistant Professor of Mechanical Engineering, Kentucky Agricultural and Mechanical College............	1899
Farewell, Elmer S....... 30 Broad Street, New York.	Steam Engineer, International Paper Co............	1895
Fernald, Robert H........ Cleveland, O.	Assistant Professor of Mechanical Engineering, Case School of Applied Science	1899
Fisher, James, Jr......... Houghton, Mich.	Instructor in Mathematics and Physics, Michigan College of Mines..	1899
Flather, John J.......... Minneapolis, Minn.	Professor of Mechanical Engineering, University of Minnesota...........	1893
Fletcher, Robert......... Hanover, N. H.	Professor of Civil Engineering, Director of Thayer School of Civil Engineering, Dartmouth College........	1894
Flint, Walter............ Orono, Me.	Professor of Mechanical Engineering, University of Maine..............	1898

Name and Address.	Title.	Date of Membership.
Foss, Fred. E. State College, Pa.	Professor of Civil Engineering, Pennsylvania State College	1893
Frankforter, George B. Minneapolis, Minn.	Professor of Chemistry, University of Minnesota	1897
Franklin, William S. Bethlehem, Pa.	Professor of Electrical Engineering, Lehigh University	1900
French, Arthur W. Worcester, Mass.	Professor of Civil Engineering, Worcester Polytechnic Institute	1900
French, Thomas E. Columbus, O.	Associate Professor of Architecture and Drawing, Ohio State University.	1899
Fuertes, Estevan A. Ithaca, N. Y.	Director and Dean of College of Civil Engineering, Cornell University	1894
Fullan, M. Thomas J. Auburn, Ala.	Assistant in Mechanical Engineering, Alabama Polytechnic Institute	1897
Fuller, Almon H. University Station, Seattle, Wash.	Professor of Civil Engineering, University of Washington	1901
Fulton, Henry Boulder, Colo.	Professor of Civil Engineering, University of Colorado	1894
Galbraith, John Toronto, Ont.	Principal and Professor of Engineering, School of Practical Science	1893
Giesecke, F. E. College Station, Tex.	Professor of Drawing, Texas Agricultural and Mechanical College	1893
Gill, James H. Minneapolis, Minn.	Instructor in Machine and Tool Construction, University of Minnesota	1896
Goldsborough, Winder E. Lafayette, Ind.	Professor of Electrical Engineering, Director of the Electrical Laboratory, Purdue University	1897
Goodenough, George A. Urbana, Ill.	Assistant Professor of Mechanical Engineering, University of Illinois	1900
Goodman, John Leeds, England.	Professor of Engineering, Yorkshire College, Victoria University	1893
Goss, William F. M. Lafayette, Ind.	Professor of Experimental Engineering, Director of Engineering Laboratories, Purdue University	1893

Name and Address.	Title.	Date of Membership.
Gray, Thomas............ Terre Haute, Ind.	Professor of Dynamic Engineering, Rose Polytechnic Institute.........	1895
Griffin, Charles L....... State College, Centre Co., Pa.	Assistant Professor of Machine Design, Pennsylvania State College....	1900
Groat, Benjamin F........ Minneapolis, Minn.	Assistant Professor of Mathematics and Mechanics, School of Mines, University of Minnesota...........	1899
Grover, Nathan C......... Orono, Me.	Professor of Civil Engineering, University of Maine..............	1894
Hall, Christopher W.... Minneapolis, Minn.	Professor of Geology and Mineralogy, University of Minnesota...........	1894
Halsted, George B....... Austin, Tex.	Professor of Mathematics, University of Texas...............	1899
Hamlin, George H........ Orono, Me.	Civil Engineer....................	1895
Harper, Joseph D........ St. Louis, Mo.	Manager of Machinery Department, Fairbanks, Morse & Co.............	1899
Harris, Abram W........ Orono, Me.	President, University of Maine...............	1897
Harris, Elmo G.......... Rolla, Mo.	Professor of Engineering, Missouri School of Mines..........	1894
Hatt, William K........ Lafayette, Ind.	Associate Professor of Applied Mechanics, Purdue University......	1895
Hawes, Joseph H......... Durham, N. H.	Associate Professor of Drawing, New Hampshire College of Agriculture and the Mechanic Arts........	1900
Haynes, Arthur E........ Minneapolis, Minn.	Professor of Mathematics, University of Minnesota............	1895
Hazen, John V........... Hanover, N. H.	Professor of Civil Engineering, Dartmouth College................	1896
Hibbard, H. Wade........ Ithaca, N. Y.	Professor of Mechanical Engineering of Railways, Sibley College, Cornell University	1896
Hill, John E............ Providence, R. I.	Professor of Civil Engineering, Brown University.................	1894

Name and Address.	Title.	Date of Membership.
Hitchcock, Embury A.... Columbus, Ohio.	Professor of Experimental Engineering, Ohio State University.........	1899
Hoag, William R........ Minneapolis, Minn.	Professor of Civil Engineering, University of Minnesota............	1893
Hofman, Heinrich O...... Boston, Mass.	Professor of Metallurgy, Massachusetts Institute of Technology.......	1894
Holden, Charles A....... Hanover, N. H.	Instructor in Civil Engineering and Mathematics, Thayer School of Civil Engineering, Dartmouth College....	1901
Hollis, Ira N............ Cambridge, Mass.	Professor of Engineering, Harvard University...............	1894
Hood, Ozni P............ Houghton, Mich.	Professor of Mechanical and Electrical Engineering, Michigan College of Mines	1893
Hoskins, Leander M...... Stanford University, California.	Professor of Applied Mechanics, Leland Stanford Junior University..	1893
Howe, Malverd A........ Terre Haute, Ind.	Professor of Civil Engineering, Rose Polytechnic Institute.........	1894
Hume, Alfred............ University, Miss.	Professor of Mathematics and Acting Professor of Civil Engineering, University of Mississippi..............	1894
Humphreys, David C...... Lexington, Va.	Professor of Civil Engineering, Washington and Lee University.....	1893
Hutton, Frederick R...... New York, N. Y.	Professor of Mechanical Engineering, Columbia University...............	1894
Ives, Howard C.......... Worcester, Mass.	Instructor in Civil Engineering, Worcester Polytechnic Institute....	1901
Jackson, Dugald C........ Madison, Wis.	Professor of Electrical Engineering, University of Wisconsin...........	1893
Jackson, John P.......... State College, Pa.	Professor of Electrical Engineering, Pennsylvania State College........	1894
Jacobus, D. S............ Hoboken, N. J.	Professor of Experimental Mechanics and Engineering Physics, Stevens Institute of Technology....	1893
Jacoby, Henry S.......... Ithaca, N. Y.	Professor of Bridge Engineering and Graphics, Cornell University.......	1894

Name and Address.	Title.	Date of Membership.
Johnson, John B. Madison, Wis.	Dean of College of Mechanics and Engineering, University of Wisconsin	1893
Johnson, Lewis J. Cambridge, Mass.	Assistant Professor of Civil Engineering, Lawrence Scientific School, Harvard University	1898
Jones, Clement R. Morgantown, W. Va.	Professor of Mechanical Engineering, West Virginia University	1895
Jones, Forrest R. Worcester, Mass.	Professor of Machine Design, Worcester Polytechnic Institute	1893
Kay, Edgar B. Ithaca, N. Y.	Instructor in Civil Engineering, Cornell University	1898
Kent, William Passaic, N. J.	Consulting Engineer, Associate Editor of 'Engineering News,' New York City	1894
Kidwell, Edgar Hancock, Mich.	Superintendent, Arcadian Copper Mining Company	1896
Kimball, Rodney G. Brooklyn, N. Y.	Professor of Applied Mathematics, The Polytechnic Institute of Brooklyn	1894
Kinealy, J. H. St. Louis, Mo.	Professor of Mechanical Engineering, Washington University	1893
Kingsbury, Albert Worcester, Mass.	Professor of Applied Mechanics, Worcester Polytechnic Institute	1893
Knoch, Julius J. Fayetteville, Ark.	Professor of Civil Engineering, University of Arkansas	1898
Kyser, Henry H. Auburn, Ala.	Instructor in Physics, Director of Physical Laboratory, Alabama Polytechnic Institute.	1897
Ladd, George E. Rolla, Mo.	Director and Professor of Geology and Mining, School of Mines and Metallurgy	1901
Lambert, Preston A. South Bethlehem, Pa.	Assistant Professor of Mathematics, Lehigh University	1897
Landreth, Olin H. Schenectady, N. Y.	Professor of Civil Engineering, Union College	1893
Lane, Henry M. Scranton, Pa.	Principal School of Metal Mining, International Correspondence Schools	1900

Name and Address.	Title.	Date of Membership.
Lanphear, Burton S. Ames, Iowa.	Assistant Professor of Electrical Engineering, Iowa State College	1897
Lanza, Gaetano. Boston, Mass.	Professor of Applied Mechanics, in charge of the Department of Mechanical Engineering, Massachusetts Institute of Technology	1893
La Rue, Benjamin F. Scranton, Pa.	Principal School of Civil Engineering, International Correspondence Schools	1899
Lawrence, James W. Fort Collins, Colo.	Professor of Mechanical Engineering, State Agricultural College	1898
Lord, Nathaniel W. Columbus, O.	Professor of Metallurgy and Mineralogy, Ohio State University	1899
Love, Andrew C. College Station, Tex.	Assistant Professor of Drawing, Agricultural and Mechanical College of Texas	1900
McClintock, William E. 15 Court Square, Boston, Mass.	Civil Engineer, Instructor in Highway Engineering, Harvard University, Cambridge, Mass	1898
McColl, Jay R. Knoxville, Tenn.	Professor of Mechanical Engineering, University of Tennessee	1894
McNair, Frederick W. Houghton, Mich.	President, Michigan College of Mines.	1897
Mack, John G. D. 222 Jefferson St., Madison, Wis.	Assistant Professor of Machine Design, College of Engineering, University of Wisconsin	1901
Magowan, Charles S. Iowa City, Iowa.	Assistant Professor of Civil Engineering, State University of Iowa	1896
Magruder, William T. Columbus, Ohio.	Professor of Mechanical Engineering, Ohio State University	1893
Marburg, Edgar. Philadelphia, Pa.	Professor of Civil Engineering, University of Pennsylvania	1894
Marston, Anson. Ames, Iowa.	Professor of Civil Engineering, Iowa State Agricultural College	1894
Marvin, Frank O. Lawrence, Kan.	Dean of the School of Engineering, Professor of Civil Engineering, University of Kansas	1893

Name and Address.	Title.	Date of Membership.
Marx, Charles D......... Stanford University, Cal.	Professor of Civil Engineering, Leland Stanford Junior University..	1893
Mather, Thomas W....... New Haven, Conn.	Principal Boardman Manual Training High School......................	1894
Mathews, Hubert B...... Brookings, S. Dak.	Professor of Physics, South Dakota Agricultural College..	1896
Matthews, Charles P.... Lafayette, Ind.	Associate Professor of Electrical Engineering, Purdue University.......	1898
Maurer, Edward R....... Madison, Wis.	Professor of Mechanics, University of Wisconsin.	1897
Mead, Elwood............ Washington, D. C.	Professor of the Institutions and Practice of Irrigation, University of California; Expert in charge of Irrigation Investigations of the U. S. Department of Agriculture.........	1901
Mees, Carl L............ Terre Haute, Ind.	President, Rose Polytechnic Institute..........	1894
Mendenhall, Thomas C... Worcester, Mass.	....	1895
Merriman, Mansfield..... South Bethlehem, Pa.	Professor of Civil Engineering, Lehigh University.................	1893
Miller, Robert S......... Lafayette, Ind.	Assistant Professor of Mechanical Engineering, Purdue University......	1900
More, Charles C......... 222 Rochelle Ave., Philadelphia, Pa.	With Eastern District, American Bridge Co., Pencoyd, Pa............	1901
Morley, Frederick........ Lapeer, Mich.	Res. Engr. St. Clair Flats Survey for the State of Michigan.............	1896
Munroe, Henry S......... New York, N. Y.	Professor of Mining, Columbia University...............	1893
Nagle, James C.......... College Station, Tex.	Professor of Civil Engineering, Agricultural and Mechanical College of Texas..........................	1897
Neff, Frank H........... Cleveland, Ohio.	Professor of Civil Engineering, Case School of Applied Science...........	1895

Name and Address.	Title.	Date of Membership.
Norris, Henry H.......... Ithaca, N. Y.	Assistant Professor of Electrical Engineering and Electrician to the Department of Light, Heat and Power, Cornell University................	1900
Ordway, John M........... New Orleans, La.	Professor of Applied Chemistry, Acting Professor of Civil Engineering, Tulane University.................	1894
Orton, Edward, Jr......... Columbus, Ohio.	Professor of Ceramics and Director of the Department of Clay Working and Ceramics, Ohio State University....	1900
Ostrander, John E........ Amherst, Mass.	Professor of Mathematics and Civil Engineering, Massachusetts Agricultural College.....................	1894
Owens, Robert B.......... Montreal, Que.	Professor of Electrical Engineering, McGill University.................	1894
Palmer, Walter K......... Kansas City, Mo.	Mechanical Engineer.	1899
Peabody, Cecil H......... Boston, Mass.	Professor of Marine Engineering and Naval Architecture, Massachusetts Institute of Technology............	1894
Pence, William D......... Lafayette, Ind.	Professor of Civil Engineering, Purdue University................	1895
Pettee, Charles H....... Durham, N. H.	Professor of Mathematics, New Hampshire College......................	1898
Phillips, James D........ Champaign, Ill.	Assistant Professor of Engineering Drawing, University of Illinois.....	1899
Porter, Dwight.......... Boston, Mass.	Professor of Hydraulic Engineering, Massachusetts Institute of Technology	1893
Porter, J. Madison........ Easton, Pa.	Professor of Civil Engineering, Lafayette College..................	1893
Price, Melvin............ Lincoln, Neb.	Assistant Instructor in Mechanical Drawing and Machine Design, University of Nebraska...............	1900
Pupin, Michael I......... New York, N. Y.	Adjunct Professor of Mechanics, Columbia University..............	1895

Name and Address.	Title.	Date of Membership.
Puryear, Charles........ College Station, Tex.	Professor of Mathematics, Agricultural and Mechanical College of Texas	1901
Randolph, Lingan S...... Blacksburg, Va.	Professor of Mechanical Engineering, Virginia Polytechnic Institute......	1894
Raymond, William G...... Troy, N. Y.	Professor of Geodesy and Road Engineering, Rensselaer Polytechnic Institute	1893
Reber, Louis E........... State College, Pa.	Professor of Mechanical Engineering, Pennsylvania State College.........	1893
Rice, Arthur L........... 12 West 31st St., New York, N. Y.	Assistant to the Secretary of the American Society of Mechanical Engineers	1894
Richards, Charles R...... Lincoln, Neb.	Professor of Practical Mechanics, Director of the School of Mechanic Arts, University of Nebraska......	1895
Richards, Robert H...... Boston, Mass.	Professor of Mining Engineering and Metallurgy, Massachusetts Institute of Technology....................	1895
Richter, Arthur W....... Madison, Wis.	Assistant Professor of Steam Engineering, University of Wisconsin....	1894
Ricker, Nathan C........ Urbana, Ill.	Dean of College of Engineering, University of Illinois..............	1894
Ricketts, Palmer C...... Troy, N. Y.	President and Director, Rensselaer Polytechnic Institute....	1893
Riggs, Walter M......... Clemson College, S. C.	Professor of Electrical Engineering, and Director of the Mechanical Department, Agricultural and Mechanical College of South Carolina......	1897
Ripper, William.......... Sheffield, Eng.	Professor of Engineering, University College................	1893
Robbins, Arthur G........ Boston, Mass.	Assistant Professor of Highway Engineering, Massachusetts Institute of Technology	1894
Robinson, Edward........ Potsdam, N. Y.	Professor of Mechanical Engineering, Clarkson School of Technology......	1899
Robinson, Frederick H.... Newark, Del.	Professor of Civil Engineering, Delaware College..................	1894

Name and Address.	Title.	Date of Membership.
Robinson, Stillman W.... Columbus, Ohio.	Mechanical Engineer and Expert, 1353 Highland St................	1893
Rosebrugh, Thomas R.... Toronto, Ontario.	Lecturer in Electrical Engineering, School of Practical Science.........	1896
Ryan, Harris J........... 114 Cascadilla Place, Ithaca, N. Y.	Professor of Electrical Engineering, Sibley College, Cornell University..	1901
Sanborn, Frank E........ Columbus, O.	Director Industrial Arts Department, Ohio State University..............	1899
Schmidt, Edward C....... Urbana, Ill.	Assistant Professor of Railway Engineering, University of Illinois.....	1899
Schuerman, William H... Nashville, Tenn.	Dean of the Engineering Department, Professor of Civil Engineering, Vanderbilt University.................	1895
Sedgwick, William T..... Boston, Mass.	Professor of Biology, Massachusetts Institute of Technology............	1896
Shepardson, George D.... Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota...........	1895
Smart, Richard A........ Lafayette, Ind.	Associate Professor of Experimental Engineering, Purdue University....	1896
Smith, Harold B.......... Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute....	1898
Smith, Harry E.......... Brooklyn, N. Y.	Assistant Professor of Mechanical Engineering, Pratt Institute..........	1895
Smith, Herbert S. S...... Princeton, N. J.	Professor of Applied Mechanics, Princeton University..............	1894
Snow, Charles H......... New York, N. Y.	Dean of School of Applied Science, New York University..............	1895
Snow, Walter B......... 29 Russel Ave., Watertown, Mass.	Mechanical Engineer, B. F. Sturtevant Co., Jamaica Plain, Mass..........	1899
Solberg, Halvor C........ Brookings, S. D.	Professor of Mechanical Engineering, South Dakota Agricultural College..	1894
Spalding, Frederick P.... Columbia, Mo.	Professor of Civil Engineering, University of State of Missouri.....	1893

Name and Address.	Title.	Date of Membership.
Spangler, Henry W...... Philadelphia, Pa.	Professor of Mechanical Engineering, University of Pennsylvania.........	1893
Sperr, Frederick W....... Houghton, Mich.	Professor of Civil and Mining Engineering, Michigan College of Mines..	1896
Spinney, Louis B......... Ames, Iowa.	Professor of Physics and Electrical Engineering, Iowa State Agricultural College	1899
Springer, Frank W....... Minneapolis, Minn.	Instructor in Electrical Engineering, University of Minnesota...........	1896
Staley, Cady............. Cleveland, Ohio.	President, Case School of Applied Science......	1894
Stanwood, James B...... Cincinnati, Ohio.	Director, Technical School of Cincinnati......	1894
Stevens, James S......... Orono, Me.	Professor of Physics, University of Maine...............	1898
Stewart, Clinton B...... Anchor, Ill.	Civil Engineer.....................	1894
Stewart, Lewis B......... Toronto, Ontario.	Lecturer in Surveying, School of Practical Science........	1897
Stout, Oscar Van P...... Lincoln, Neb.	Professor of Civil Engineering, University of Nebraska................	1894
Stubbs, Joseph E......... Reno, Nev.	President, Nevada State University...........	1897
Swain, George F.......... Boston, Mass.	Professor of Civil Engineering, Massachusetts Institute of Technology....	1893
Talbot, Arthur N........ Urbana, Ill.	Professor of Municipal and Sanitary Engineering, University of Illinois..	1893
Taylor, William D....... 415 Wisconsin Ave., Madison, Wis.	Professor of Railway Engineering, University of Wisconsin............	1894
Thaler, Joseph A........ Bozeman, Montana.	Assistant Professor of Mechanical Engineering, Montana Agricultural and Mechanical College............	1901
Thomas, Robert G........ Charleston, S. C.	Professor of Mathematics and Engineering, South Carolina Military Academy...	1894

Name and Address.	Title.	Date of Membership.
Thompson, William O.... Columbus, O.	President, Ohio State University.............	1899
Thornburg, Charles L.... South Bethlehem, Pa.	Professor of Mathematics and Astronomy, Lehigh University............	1894
Thurston, Robert H....... Ithaca, N. Y.	Director of Sibley College, Cornell University................	1893
Timmerman, Arthur H.... St. Louis, Mo.	Assistant Superintendent Wagner Electric Mfg. Co.................	1894
Towle, William M........ State College, Pa.	Assistant Professor of Practical Mechanics, Pennsylvania State College.	1895
Turneaure, Frederick E.. Madison, Wis.	Professor of Bridge and Sanitary Engineering, University of Wisconsin..	1894
Turner, Daniel L........ Cambridge, Mass.	Instructor in Surveying and Hydraulics, Lawrence Scientific School, Harvard University...............	1898
Turner, William P....... Lafayette, Ind.	Instructor in Machine Work, Purdue University................	1900
Tyler, Harry W.......... 419 Boylston St., Boston, Mass.	Professor of Mathematics, and Secretary, Massachusetts Institute of Technology	1894
Van Ornum, J. L.......... St. Louis, Mo.	Professor of Civil Engineering, Washington University............	1895
Vedder, Herman K....... Agricultural College, Mich.	Professor of Mathematics and Civil Engineering, Michigan State Agricultural College.	1894
Waddell, J. A. L.......... Kansas City, Mo.	Consulting Bridge Engineer, of Waddell and Hedrick..................	1893
Wadsworth, Joel E...... 22 Marsemere Place, Yonkers, N. Y.	Assistant Chief Engineer, Operating and Engineering Department, Eastern Division, American Bridge Co...	1895
Wadsworth, M. Edward... State College, Pa.	Professor of Mining and Geology, Pennsylvania State College........	1895
Waldo, Clarence A....... Lafayette, Ind.	Professor of Mathematics, Purdue University.................	1897
Walker, Elton D......... State College, Pa.	Assistant Professor of Civil Engineering, Pennsylvania State College....	1895
Webb, Howard S.......... Orono, Me.	Professor of Electrical Engineering, University of Maine...............	1897

Name and Address.	Title.	Date of Membership.
Wells, James H. 624 N. Sixth Street, Lafayette, Ind.	Mechanical Engineer	1897
Whipple, George C. Brooklyn, N. Y.	Director of Mt. Prospect Laboratory, Flatbush Ave. and Eastern Parkway.	1896
White, James McLaren Champaign, Ill.	Associate Professor of Architecture, University of Illinois	1900
Willett, James R. 434 Jackson Boulevard, Chicago, Ill.	Architect	1896
Williams, Frank B. 12 Gillespie Street, Schenectady, N. Y.	Associate Professor of Engineering, Union College	1901
Williams, Sylvester N. Mt. Vernon, Iowa.	Professor of Civil Engineering, Cornell College	1893
Williston, Arthur L. Brooklyn, N. Y.	Director Department of Science and Technology, Pratt Institute	1897
Wilmore, John J. Auburn, Ala.	Professor of Mechanical Engineering, Alabama Polytechnic Institute	1894
Wilson, Victor T. Ithaca, N. Y.	Instructor in Freehand and Mechanical Drawing, Cornell University	1898
Wing, Charles B. Stanford University, California.	Professor of Structural Engineering, Leland Stanford Junior University	1895
Wood, Arthur J. Worcester, Mass.	Instructor in Mechanical Engineering, Worcester Polytechnic Institute	1898
Woodward, Calvin M. St. Louis, Mo.	Dean of the School of Engineering and Architecture, Washington University, St. Louis	1894
Woodward, Robert S. New York, N. Y.	Professor of Mechanics, Columbia University	1893
Wright, Charles H. C. Toronto, Ont.	Lecturer in Architecture, School of Practical Science	1897
Ziwet, Alexander Ann Arbor, Mich.	Professor of Mathematics, University of Michigan	1897

GEOGRAPHICAL DISTRIBUTION OF MEMBERS.

Alabama	4	Michigan	11	Tennessee	3
Arkansas	1	Minnesota	12	Texas	5
California	5	Mississippi	1	Vermont	1
Colorado	4	Missouri	10	Virginia	2
Connecticut	4	Nebraska	4	Washington	1
Delaware	1	Nevada	1	West Virginia	2
Illinois	14	New Hampshire	5	Wisconsin	9
District of Columbia	1	New Jersey	4	Argentine Republic	1
Indiana	15	New Mexico	1	Australia	1
Iowa	7	New York	32	Canada	6
Kansas	2	Ohio	18	England	2
Kentucky	3	Pennsylvania	22		
Louisiana	4	Rhode Island	2	Total	261
Maine	6	South Carolina	2		
Massachusetts	30	South Dakota	2		

36 States, 1 Territory, District of Columbia, Canada, and 3 Foreign Countries.

DECEASED MEMBERS.

NAME.	YEAR OF ELECTION.	DATE OF DEATH.	MEMOIR. Vol.	Page.
VOLNEY G. BARBOUR	1894	June 4, 1901.	IX,	...
CHARLES B. BRUSH	1893	June 3, 1897.	VII,	181
ECKLEY B. COXE	1894	May 13, 1895.	VII,	182
FRANCIS R. FAVA, JR.	1894	March 28, 1896.	VII,	183
HERBERT G. GEER	1894	March 7, 1900.	VIII,	371
JUSTUS M. SILLIMAN	1894	April 15, 1896.	VII,	184
JAMES H. STANWOOD	1894	May 24, 1896.	VII,	185
ALPHONSE N. VAN DAELL	1897	March 28, 1899.	VII,	186
JOHN R. WAGNER	1894	January 21, 1899.	VII,	187
FRANCIS A. WALKER	1896	January 5, 1897.	VII,	188
NELSON O. WHITNEY	1893	March 17, 1901.	IX,	...
DE VOLSON WOOD	1893	June 27, 1897.	V,	325

PAST OFFICERS.

Special Committee for Division E (Engineering Education), World's Engineering Congress, 1893.

IRA O. BAKER, Chairman, HENRY T. EDDY, Vice-Chairman,
WM. R. HOAG, Secretary, C. FRANK ALLEN, Secretary, *pro tem.*
MORTIMER E. COOLEY, SAMUEL W. STRATTON,
STORM BULL.

PRESIDENTS.

DE VOLSON WOOD,* 1893–4,
GEORGE F. SWAIN, 1894–5,
MANSFIELD MERRIMAN, 1895–6,
HENRY T. EDDY, 1896–7,
JOHN B. JOHNSON, 1897–8,
THOS. C. MENDENHALL, 1898–9,
IRA O. BAKER, 1899–1900,
FRANK O. MARVIN, 1900–01.

VICE-PRESIDENTS.

SAMUEL B. CHRISTY, GEORGE F. SWAIN, 1893–4,
ROBERT H. THURSTON, FRANK O. MARVIN, 1894–5,
FRANK O. MARVIN, CADY STALEY, 1895–6,
JOHN GALBRAITH, JOHN M. ORDWAY, 1896–7,
THOMAS C. MENDENHALL, HARRY W. TYLER, 1897–8,
C. FRANK ALLEN, HENRY W. SPANGLER, 1898–9,
ROBERT FLETCHER, CHARLES D. MARX, 1899–1900,
THOMAS GRAY, ALBERT KINGSBURY, 1900–01.

TREASURERS.

STORM BULL, 1893–5,
JOHN J. FLATHER, 1895–9.

SECRETARIES.

JOHN B. JOHNSON, 1893–5,
C. FRANK ALLEN, 1895–7,
ALBERT KINGSBURY, 1897–9,
EDGAR MARBURG, 1899–1900.

* Died June 27, 1897.

Members of Previous Councils.

Terms of Office Expired in 1894.

M. E. Cooley, H. T. Eddy, W. F. M. Goss,
W. R. Hoag, S. W. Robinson, H. W. Spangler,
R. H. Thurston.

Terms of Office Expired in 1895.

H. T. Bovey, W. H. Burr, O. H. Landreth,
Mansfield Merriman, W. G. Raymond, G. F. Swain,
De Volson Wood.*

Terms of Office Expired in 1896.

I. O. Baker, Storm Bull, S. B. Christy,
John Galbraith, J. B. Johnson, F. O. Marvin,
C. D. Marx.

Terms of Office Expired in 1897.

H. T. Eddy, J. J. Flather, J. P. Jackson,
Albert Kingsbury, L. S. Randolph, S. W. Robinson,
R. H. Thurston.

Terms of Office Expired in 1898.

C. F. Allen, C. L. Mees, Mansfield Merriman,
J. M. Ordway, W. G. Raymond, Cadey Staley,
R. S. Woodward.

Terms of Office Expired in 1899.

Arthur Beardsley, Robert Fletcher, John Galbraith,
William Kent, T. C. Mendenhall, W. H. Schuerman,
M. E. Wadsworth.

Terms of Office Expired in 1900.

Storm Bull, L. G. Carpenter, Albert Kingsbury,
F. O. Marvin, R. B. Owens, R. L. Sackett,
R. H. Thurston.

Terms of Office Expired in 1901.

T. M. Drown, M. A. Howe, I. N. Hollis,
Gaetano Lanza, P. C. Ricketts, R. G. Thomas,
C. M. Woodward.

Died June 27, 1897.

CONSTITUTION

OF THE

Society for the Promotion of Engineering Education.

1. NAME.—This organization shall be called the SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

2. MEMBERS.—Members of the Society shall be those who occupy, or have occupied, responsible positions in the work of engineering instruction, together with such other persons as may be recommended by the Council.

Honorary Members of the Society shall be such persons as may be recommended by unanimous vote of the Council after a letter ballot. They shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

The name of each candidate for membership shall be proposed in writing to the Council by two members to whom he is personally known. Such name, if approved by the Council, shall be voted on by the Society at the annual meeting.

3. OFFICERS.—There shall be a President, two Vice-Presidents, a Secretary and a Treasurer, each to hold office for one year. They shall be chosen by vote of the members at the annual meeting.

4. COUNCIL.—The Council of this Society shall consist of twenty-one elective members, one-third of whom shall retire annually. The officers and the past Presidents of the Society shall be members of the Council *ex officiis*.

Any member of this Society shall be eligible to election to the Council, provided that not more than one elective member shall be from any one college.

Members of the Council shall be elected by ballot by the Society, at its annual meeting.

The Council shall constitute a general executive body of the Society, pass on proposals for membership, attend to all business of the Society, receive and report on propositions for amendments to the constitution, and shall have power to fill temporary vacancies in the offices.

5. NOMINATING COMMITTEE.—The Nominating Committee shall consist of the Past Presidents and the seven elective members of the Council retiring the following year, provided, however, that if, of this committee, the number in attendance at any

meeting be less than five, the President shall make appointments so as to form a committee of five.

6. FEES AND DUES.—The admission fee, which shall also include the first year's dues, shall be three dollars, and the annual dues thereafter three dollars, payable at the time of the annual meeting. Those in arrears more than one year shall not be entitled to vote, nor to receive copies of the Proceedings, and such members shall be notified thereof by the Secretary one month previous to the annual meeting. Any member who shall be in arrears more than two years and shall have been duly notified by the Secretary, shall be thereby dropped from the roll, excepting such arrearage shall be paid previous to the next ensuing annual meeting; and no such member shall be restored until he has paid his arrears.

7. MEETINGS.—There shall be a regular meeting occurring at the time and place of the meeting of the American Association for the Advancement of Science, or of some one of the National Engineering Societies, or otherwise as the Council may determine.

8. PUBLICATION.—The Proceedings of the Society, and such papers or abstracts as may be approved by the Council, shall be published as soon as possible after each annual meeting.

9. AMENDMENTS.—This Constitution may be amended by a two-thirds vote at any regular meeting, the amendment having been approved by a two-thirds vote of the Council, taken by letter ballot.

RULES GOVERNING THE COUNCIL.

First. The officers of the Society shall constitute a committee to arrange the time and place of the annual meeting, and also to prepare a programme for the same.

Second. The President, Secretary and Treasurer shall constitute an executive committee, which shall have charge of all matters relating to the business affairs of the Society not otherwise provided for.

Third. The reading of papers shall be limited to fifteen minutes each, and abstracts of the same of about three hundred words or less shall be printed when practicable and distributed in advance to the members.

Fourth. The time occupied by each person in the discussion of any paper shall not exceed five minutes.

PROCEEDINGS.

SATURDAY, JUNE 29, 1901.

MORNING SESSION, 10 O'CLOCK.

The ninth annual meeting of the Society was held in Buffalo, N. Y., June 29, July 1 and 2, 1901.

The meeting was called to order by the President, Frank O. Marvin.

The reports of the Secretary and Treasurer were read and accepted. The President announced that the Treasurer's report had been referred by the Council to an Auditing Committee, consisting of Professors F. W. McNair and J. C. Nagle.

The following applicants, approved by the Council, were elected members of the Society: Harris J. Ryan, Lindsay Duncan, Walter G. Berg, Charles C. More, Joseph A. Thaler, Frank B. Williams, Elwood Mead, George E. Ladd, Almon H. Fuller, John G. D. Mack, Charles A. Holden, Howard C. Ives, and Arthur D. Dean.

The Secretary presented the proposed amendment to the Constitution, referred to in his report, and which reads as follows:

"NOMINATING COMMITTEE.—The Nominating Committee shall consist of the past Presidents and the seven retiring elective members of the Council; provided, however, that if, of this committee, the number

in attendance at any meeting be less than five, the President shall make appointments so as to form a committee of five."

Objection being made that the proposed amendment would tend to discourage the selection of officers from the retiring members of the Council, it was referred to the Council, with instructions to modify the proposed amendment by substituting the second set of councilors for the first set.

The literary exercises of the meeting were opened with the delivery of the Annual Address by the President, Frank O. Marvin, on "The Cultural Value of Engineering Education."

Professor Olin H. Landreth then read his paper on "A Study of the Principle of Administration in Engineering Schools." The following members took part in the discussion: Professors Randolph, McNair, E. Robinson, Allen, Kent and Humphreys.

The next paper on "The Arrangement of Undergraduate Courses in Electrical Engineering" was read by the author, Professor John P. Jackson, and discussed by Professors Emory, D. C. Jackson, Allen, Randolph, Magruder and J. P. Jackson.

AFTERNOON SESSION, 2 O'CLOCK.

On a motion to reconsider the action at the morning session, by which the Council was asked to report a revision of the proposed amendment to the Constitution, the President was requested to decide whether it was within the province of the meeting to make the suggested change and then finally adopt the amendment, it being regarded as in harmony with the spirit of the

original amendment which passed the Council by letter ballot almost unanimously. The President ruled that the Society had the authority to do so without taking another letter ballot of the Council.

The amendment was then revised and adopted by a unanimous vote so as to read:

"NOMINATING COMMITTEE.—The Nominating Committee shall consist of the past Presidents and the seven elective members of the Council retiring the following year, provided, however, that if, of this committee, the number in attendance at any meeting be less than five, the President shall make appointments so as to form a committee of five."

The Nominating Committee, constituted in conformity with this requirement of the Constitution, consisted of past Presidents Merriman and Johnson, and Councilors Magruder, McNair and Wood. The President appointed Professor Johnson as chairman of the Committee.

The paper of Professor Burgess on "A Neglected Opportunity in Technical Education" was then read by Professor D. C. Jackson, and was discussed by Professors D. C. Jackson, J. B. Johnson, Landreth and Aldrich.

As a result of this paper and its discussion the following resolutions were adopted:

1. "That a committee of seven be appointed by the President to prepare lists of books on applied science and technology which are suitable for the use of libraries of various classes.

2. "That the American Library Association be requested to appoint a committee to cooperate with the committee of this Society."

The President was granted time for necessary correspondence before appointing the committee.

Professor H. W. Spangler then read his paper on "Howard Houston Hall, University of Pennsylvania," and illustrated it by numerous stereopticon views. Professors Marvin, Allen, Spangler, Waldo and Wilson took part in the discussion.

The paper on the question, "To what Extent should Modern Languages be Required in Engineering Courses," by Professor Charles L. Crandall, was read by the author and discussed by Professors J. B. Johnson, Aldrich, Kent, Nagle, Waldo, Esty, D. C. Jackson, Emory and Magruder.

Professor William M. Towle read his paper on "How the Graduation Thesis can be made most Effective in College Training." The secretary read a written discussion by Professor Rice, and Professors J. P. Jackson, Allen and Wood participated in the oral discussion.

The concluding paper of the session was that of Professor D. C. Jackson, on "The Availability of Correspondence Schools as Trade Schools." It was read by the author and then discussed by Professors Esty, Allen, Kent, J. P. Jackson and E. Robinson.

MONDAY, JULY 1, 1901.

MORNING SESSION, 10 O'CLOCK.

The Secretary presented the application for membership of George L. Colburn, duly approved by the Council, and he was then elected.

The President stated that the Auditing Committee had approved the Treasurer's Accounts and that the report was adopted by the Council.

Professor J. B. Johnson, the Chairman of the Committee on Industrial Education, made an informal verbal report, stating that the Committee distributed during the year a large number of copies of the reprints of its report, but that a considerable part of the second edition of the reprint was still on hand; that a copy was sent to every superintendent of city schools, to every principal of high schools in the larger cities and to every State superintendent of schools in the United States. He said that the Committee considered it wise to suspend further studies until the elaborate report of the Hon. Carroll D. Wright, United States Labor Commissioner, is published. Exhaustive information is being gathered by the Commissioner about various kinds of industrial education in America which it is expected to publish during the coming year. Professor Johnson, in behalf of the Committee, asked for its continuance, it being the purpose of the Committee to make another report after studying the extensive publication being prepared by the Commissioner of Labor. It was voted to accept this report as one of progress and to continue the Committee.

Professor James C. Nagle read his paper on "The Danger of Excessive Specialization in Undergraduate Engineering Courses," which was afterwards discussed by Professors J. P. Jackson, Lanza, Kent, Allen, Magruder, Norris, Landreth, J. B. Johnson, Goss, Waldo, Talbot, F. B. Williams, Harris, Allen, D. C. Jackson, and Hatt.

The next paper on "The Promotion of Engineering Education and Graduation Requirements" was read by the author, Professor William G. Raymond, and this was followed by Professor Robert Fletcher's paper entitled "Minimum Requirements for Graduation from a Curriculum of Civil Engineering," which was read by the Secretary, and this in turn by Professor Lingan S. Randolph's paper on "Requirements for Degrees in Engineering Courses," read by the author.

These three papers were considered together in the succeeding discussion in which the speakers were Professors Emory, McNair, M. Brooks, Merriman, J. B. Johnson, Kent, C. M. Woodward, Randolph, D. C. Jackson, and Raymond.

On motion, the question of the advisability of appointing a committee on requirements for the bachelor's degree in Engineering was referred to the Council for a recommendation.

AFTERNOON SESSION, 2 O'CLOCK.

Professor J. B. Johnson read some extracts from his paper on "Present Tendencies in Technical and Industrial Education" which was prepared to be read on July 3d before the Convocation of the Regents of the University of the State of New York, but which was also presented before this Society at the request of the Committee on programme.

The following members took part in the discussion of this subject: Kent, J. B. Johnson, Williston, Emory, D. C. Jackson, C. M. Woodward, and Goss.

Two papers were then read by their authors on practically the same subject, "To what Extent and in

what Direction is it Desirable for a Professor in Engineering to Accept Engineering Employment?" one by Professor C. Frank Allen, and the other by Mr. William Kent, the discussion being by Professors Nagle, J. B. Johnson, Allen and Kent. By invitation, Mr. William A. Haven, President of the Engineers' Society of Western New York, also took part in the discussion.

The next paper on "Research and Publication Among Engineering Teachers" was read by the author, Professor William S. Aldrich.

In the absence of the author, the Secretary read a paper on "Æsthetics in Engineering Design" which was prepared by Dr. Russell Sturgis at the request of the Committee on Programme.

The paper of Professor John G. D. Mack on "The Summer School for Apprentices and Artisans at the University of Wisconsin," was read by Professor D. C. Jackson, as the author was not present. Professors J. B. Johnson, C. M. Woodward, Magruder, Allen, and D. C. Jackson participated in the discussion.

Tuesday, July 2, 1901.

MORNING SESSION, 10 O'CLOCK.

Upon the recommendation of the Council, Charles Puryear was elected a member of the Society.

In the absence of the chairman and secretary, Professor J. P. Jackson read the report of the Committee on Entrance Requirements, which was followed by explanatory statements by the President and Professor Merriman. On motion the report was accepted.

Professor Merriman read the report of the Nominating Committee and the nominees were unanimously elected, as follows:

President, Robert Fletcher.

Vice-Presidents, Storm Bull and C. M. Woodward.

Secretary, Henry S. Jacoby.

Treasurer, Clarence M. Waldo.

Member of the Council, term to expire in 1903, C. Frank Allen.

Members of the Council, terms to expire in 1904, William F. M. Goss, Thomas Gray, David C. Humphreys, Olin H. Landreth, William G. Raymond, Louis E. Reber, and Lingan S. Randolph.

The President called attention to the importance of increasing the membership of the Society, and thereby extending its influence.

The paper by Professor George R. Chatburn on "A Laboratory Exercise; The Calibration of a Riehle-Gray Apparatus," was read by Professor Magruder, as the author was absent, and it was discussed by Professors Gray and Lanza.

The Secretary read the paper on "Machine Work in an Engineering College," by William P. Turner.

Professor Magruder, the chairman of the Committee on Statistics of Engineering Education, read the report of the Committee, which was afterwards discussed by Professors McNair, Merriman, J. P. Jackson, Magruder, Allen, Waldo, Gray, Randolph, Humphreys, E. G. Harris, and Talbot.

On motion the thanks of the Society were extended to the Engineers' Society of Western New York for the use of its room which was generously tendered

through its President, William A. Haven, and for other courtesies received from that Society.

It was voted to refer to the Council with power the question relating to the appointment of a Committee on Requirements for Graduation, and concerning which a different action was taken on the preceding day.

The meeting then adjourned.

The following members registered and were present at the meeting: W. S. Aldrich, C. F. Allen, M. Brooks, G. L. Colburn, C. L. Crandall, F. L. Emory, W. Esty, W. F. M. Goss, T. Gray, C. L. Griffin, E. G. Harris, W. K. Hatt, J. H. Hawes, I. N. Hollis, D. C. Humphreys, D. C. Jackson, J. P. Jackson, H. S. Jacoby, J. B. Johnson, L. J. Johnson, C. R. Jones, W. Kent, O. H. Landreth, G. Lanza, F. W. McNair, W. T. Magruder, F. O. Marvin, M. Merriman, J. C. Nagle, H. H. Norris, J. E. Ostrander, L. S. Randolph, W. G. Raymond, E. Robinson, F. E. Sanborn, H. W. Spangler, A. N. Talbot, W. M. Towle, C. A. Waldo, F. B. Williams, A. L. Williston, V. T. Wilson, A. J. Wood, and C. M. Woodward.

HENRY S. JACOBY, *Secretary.*

REPORT OF THE SECRETARY.

The membership of the Society at the opening of the last annual meeting was reported by the Secretary to number 249. At that meeting eighteen applicants for membership were elected, and during the past year one person had his membership restored by paying all dues in arrears. Six members resigned, most of whom retire from the ranks of engineering teachers.

The Society lost one of its members by death on March 17, 1901, Nelson O. Whitney, Professor of Railway Engineering of the University of Wisconsin. His name was included in the first list of members, he having been elected in 1893. A memoir will be prepared and published in the next volume of the Proceedings.

The total membership at the beginning of the meeting numbers 261, a net gain of twelve members.

In accordance with the instructions of the Council an arrangement was made at the beginning of the year by which the Engineering News Publishing Company of New York City assumed the storage and sale of the Proceedings of the Society under specified conditions.

The letter ballot of the Council which was ordered last year to determine the advisability for holding the meeting for 1901 during the exposition at Buffalo in conjunction with other engineering societies, resulted in a vote of more than two-thirds in favor of such an arrangement. The officers found it impracticable, however, to carry out the proposed plan in every respect, and accordingly decided to fix the date so as to follow immediately the annual convention of the American Society of Civil Engineers at Niagara Falls, on June 25 to 28, inclusive.

At the last meeting the Council adopted a proposal to amend the Constitution with reference to a Nominating Committee. In accordance with the requirements of the Constitution, a letter ballot of the Council was taken on the proposed amendment, which resulted in an affirmative vote in excess of the proposed two-thirds. It now remains for this meeting to give its approval by a two-thirds vote in order to complete the amendment.

Respectfully submitted,

HENRY S. JACOBY, *Secretary.*

The Secretary's report should be amended to include a reference to the death of Professor Volney G. Barbour on June 4, 1901, a notice of which did not reach the Secretary until after the meeting.—EDITORS.

Treasurer's Report.

The Treasurer of the Society would respectfully report as follows:

The total receipts during the year 1900–01 to date have been $953.88, as against $857.08 last year. Of this amount $683.50 was for current dues, last year, $582; $132 for past fees and dues, last year, $108; $95.29 from sale of Proceedings, last year, $114.25. The balance on hand this year is $287.05, as against $390.41 at the end of last year.

At this time 24 members are back on current dues only, while 10 are back on more than current dues. During the year 32 members paid up previously unpaid current dues, and 5 paid up dues covering more than one year. Sixteen mempers elect qualified by paying dues. Of the foreign members, one has paid current dues and five are delinquent.

The extraordinary expenses of the year are $181.70 for the Committee on Industrial Education, and $55.70 for the Committee on Entrance Requirements.

Respectfully submitted,

C. A. Waldo, *Treasurer.*

The following is the report in detail:

C. A. Waldo, Treasurer, in account with the Society for the Promotion of Engineering Education. Dr. to the following

Receipts.

Cash on hand, July 2, 1900	$ 390	41
Sale of Proceedings	95	29
Sale of reprints to authors	36	74
Sale of reports on American Industrial Education	6	35
Past dues	132	00
Current and future dues	683	50
Total	$1,344	29

Cr. by the following

DISBURSEMENTS.

Stenographer, New York meeting.....................$	70 00
Proceedings, Vol. VIII., printing, binding and wrapping.....................	406 00
Proceedings, Vol. VIII., postage, expressage and freight.....................	54 55
Reprints of papers, printing and expressage...........	37 92
Proceedings, Vols. I.–VII., boxing, cartage and freight to Engineering News Publishing Co., New York.....................	18 03
Committee on Industrial Education, 2,000 reprints of report, postage and expressage.....................	181 70
Committee on Entrance Requirements, printing, postage, etc.....................	55 70
Secretary's supplies and expense, printing, postage, expressage, stationery, etc. (including $40.75 on account of preceding year).....................	132 50
Secretary's honorarium.....................	50 00
Treasurer's expense, postage, revenue stamps, bank exchange.....................	35 84
Badges, 1900 and 1901.....................	15 00
Balance, cash on hand.....................	287 05
Total.....................$	1,344 29

The Auditing Committee reported to the Council that they had examined the report and made the following entry in the Treasurer's record book :

"We have compared the items in the previous record with the corresponding vouchers and have added the items and find the record correct in every particular."

[Signed] F. W. McNair,
J. C. Nagle,
Auditing Committee.

ADDRESS BY THE PRESIDENT.

FRANK O. MARVIN,

Dean of the School of Engineering, University of Kansas.

THE CULTURAL VALUE OF ENGINEERING EDUCATION.

At the very outset of this discussion is encountered a great difficulty. What is culture? The writer has been asking this of his friends. An answer has been sought for in the printed page where is recorded the best thought of the best minds. Great thoughts and lofty ideals have been disclosed, but nowhere has been found a satisfactory definition, a phrase or paragraph that succinctly and clearly sets forth the heart of the matter.

People often recognize, appreciate, and reverence its possession without being able to fully analyze and set down its elements. There is something subtle and emotional about it that eludes a close pursuit.

The reason for this perhaps lies in its essential individual quality, in its being the result of a personal life, developed, it is true, on lines similar to those used in other lives, yet including something that pertains exclusively to a human unit that is different from all other units.

Nevertheless, there seem to be certain fundamental qualities which must be possessed before a man can be classed with cultured people, qualities which are only acquired after a considerable experience in life, but which are influenced greatly by the years of student training, and therefore fit subjects for discussion

here. Far be it from the purpose of this paper to attempt a definition of culture or a setting forth of its elements in any completeness; rather the emphasizing of some things that relate to it, especially with reference to the education of young engineers.

1. The man of culture must be a thinking and reflecting being. There must be not only the ability but the habit; and this is no easy thing to acquire. Modern American life is full of hurry, full of affairs that demand instant attention, and one matter follows another with rapid succession. We get news from Pekin to-day, from Havana to-morrow and from the Philippines within a few hours. We build railways, erect bridges and fill large orders for locomotives for foreign shipment in such short space of time as to astonish the world. Men seek short cuts to fortune. In the popular opinion, the men who act quickly, the men of decision, are those who succeed. But there is a danger here. For, back of the action, behind the sharp decision, must lie a mature judgment, and how else is this to be formed except as a result of deliberate reflection? However quickly one may reach a conclusion, its correctness or faultiness will depend not on intuition but on the degree of true comprehension. The decisive act which is also right rests on a process of thinking and judging that has been long fostered until it has become a habit, until there are established certain standards by which things are to be measured.

The early steps of this training are necessarily slow and we, as teachers of engineers, must recognize this and not yield to the temptation to crowd our students

over too much ground on the one hand, or on the other to lead them through short cuts across country by empirical paths that may give them ease and quickness of travel but little or no reason why the path is chosen. Let them go the long road. I do not by any means wish our teaching to be non-practical—rather more practical in the best sense ; but first, last and all the time let students be trained to do their own thinking and to form their own judgments; to test the statements of others by the workings of their own mental processes.

2. There is another element of culture that comes in here, an ethical one, that of forming right judgments. Men may have the appearance of culture without its true spirit which is essentially honest. This is especially important as culture seeks to make a man's life satisfactory to himself when measured by his own conscience as well as successful in the field of affairs. So his standards must be based on sound principles of right and wrong; and it is only when these are so placed that his life becomes one of freedom, freedom from the bondage that wrong thinking and acting always bring. A class room is no place to preach a sermon, but there can be there imparted a respect for truth and perfect honesty. A teacher's attitude should always be open and frank, that of a sincere seeker after truth. He should never dodge an honest question and be ever ready to say, "I do not know," if he does not. There is an incalculable power that "makes for righteousness" and the happiness of the after life of the student in the true teacher's conduct of even such a material subject as mechanics.

Back behind the subject with its subdivisions, its formulæ and rules, lies something larger, a sort of spiritual quality that binds it to all other subjects, to the universe as a whole and makes it a part of the truth of God's realm. The student that gets hold of this significance learns much more than facility in the manipulations of processes or the application of principles. He gets something that makes his life richer and better and his mastery of the subject more complete.

3. There can be no true culture for a man that does not work, that does not put his cultivated powers to some useful service; and here there must be such degree of mastery over the chosen profession or business as will result in a special skill and dexterity—a doing of some one thing better than others can do it. A man expresses himself through his work, and whether he will or no he thus discloses to all who know him his own peculiar qualities. It is this intensity of application, this concentration of purpose and directness of aim that gets the world's work done. Here in early years the engineering student has the advantage of the student in arts. Study for knowledge's sake may be stimulating to the few, but for the many there is needed the goal of a special calling to secure the close application that results in ability to concentrate one's energy to the attainment of a certain end. But here again comes a danger, that of too early or over specialization, and the following of short cuts to professional life that are advocated by some who, in the eyes of the world as well as in their own, have been eminently successful as specialists. Whether

these can be called men of culture of the highest attainments is another matter. The extreme specialist may be supreme in his own line of details but may fail when there comes up a question involving the relation of his specialty to other things. Even within his own domain, his conclusions will be modified by his general knowledge and experience. All one-sided people, whether they be linguists or naturalists, poets or merchants, preachers or engineers, are quite liable to the forming of erroneous judgments. To the few geniuses, whose capacities and power seem to be abnormally developed, though of limited scope, much is forgiven; but for the average man of the day there is demanded an ability to form good and wise conclusions.

4. In order to form those that are appropriate and correct there is needed then breadth of view; a quality that has been expressed by the word poise. A man of poise, of even balance, will see things in their right relations and due proportions; he will weigh matters, giving to each component part its just degree of importance. He will the better understand the motives that underlie other men's actions and the more readily use them to suit his own purpose. He will be more apt to rightly interpret the new movements in the world of thought or action and can seize opportunity for a personal advantage or a larger sphere of service before others see that there is such.

This demands a considerable range of knowledge. Not the close mastery of many lines in all their details, but a fair degree of familiarity with their general phenomena and principles; and there is scarcely any

field that will not contribute something to the result. It is admitted at once that the average man is of limited capacity and unable to grasp a comprehension of all knowledge that may influence his life and work; what is pleaded for is such a degree of breadth as may be needed to make one of great efficiency in his chosen profession and of most value to himself, not only in a financial way, but also in the sense of gaining a joyful recognition of the worth of developing all the powers that one has.

The value of mathematics and the physical sciences with their applications to technical things needs no discussion here, for these are the engineer's tools; but it is a fair question whether in our desire to graduate students that can be early useful we do not place too much stress on technical things to the exclusion of others that give greater breadth of training. We must not forget that we are educating men for a life; that we must look forward to the time when these young people will be fifty years old and at the period of their maximum productiveness as workers and of maximum value in society and as citizens. Engineers have to deal with other things beside materials and physical laws; they must manage men and matters of finance. If they are to rightly influence those whose capital they are employed to expend, they must be able to meet them socially and intellectually, to discuss intelligently matters outside the pale of strictly professional life. Evidence of professional ability and skill is of course at first demanded, but breadth of culture creates an added confidence in the wisdom of the conclusions reached and the advice given.

Heretofore much of our engineering work has been concerned with the opening and developing of new country or new business and industrial enterprises. So engineers have found their work away from contact with men. But engineering practice is changing as conditions become older and more settled, and more and more practitioners find their work in communities and busy centers of trade where they are constantly thrown into close contact with strong and cultured men. Present engineering courses do little to prepare a man for this thorough instruction concerning human nature and human relations. Something of history, economics and sociology should be included.

5. It is not sufficient to form correct judgments only; there must be added a skillful and effective presentation of them in well chosen and fitting English. The ability to do this involves more than training in the writing of compositions, themes, forensics and reports. The cultured man should have a taste for reading the best that has been written in his mother tongue and for several reasons: The great thoughts of great minds are stimulating and broadening to his own mind; he thereby absorbs a knowledge of words and their shades of meaning; he gains an appreciation of style and insensibly better knows how to form his own; and not least by any means he makes of his books friends that are life long, that cheer and console him under all happenings, adding much to his internal resources for happiness. The time given to English in our courses is not enough to properly train students in its use and at the same time

open the doors to our best literature. It may be said that all of this English work should be done in the preparatory school, and it is probably true that the character and quality of the high school English is better to-day than it has been heretofore. Yet it seems to me that engineering students should have some training of a college grade along the lines of literature.

6. To the writer's mind there is another element of culture that should enter into an engineer's training, viz: an appreciation for beauty. As he has said at another time, the engineer is a designer, and it is important that he should embody his design in an artistic form if he is to fulfill his whole mission and please and gratify others by the perfection of his work. The engineering student devotes a good share of his time to the drawing board, and much can be done here toward the cultivation of this quality by an instructor who possesses it, without lessening at all the amount or force of the technical exercises for which the process is primarily used. There should be, however, something further by way of giving instruction in elementary æsthetics and by opening the students eyes to what is beautiful in nature.

7. The possession of agreeable manners and tact is another evidence of culture. Not merely the conventional bearing of polite society, though this has its value. This alone is but a husk which must cover the real kernel, refined and gentle feeling; and such feeling is the result of moral and intellectual convictions. Manners then are not to be taught from a text or by lecture; they rather follow as a consequence from

the whole course of training and are crude or refined just as the character of the instruction makes them. The teacher's personality has very much to do with this matter. If he is of coarse grain, of domineering or selfish disposition, his influence will not tend toward the production of true gentlemen.

And now for the real question—does engineering education tend to produce culture? According to old standards when men limited culture chiefly to a knowledge of language, literature and philosophy, the reply would be in the negative. However, standards are not the thing itself, only methods of measurement; moreover, standards change. Science has modified and is still changing the ideas of culture that men hold and this evolution makes it all the more difficult to find a common ground upon which all can stand when considering things concerning it. This much is clear, however, that no one existing course of educational training has a monopoly of cultural methods; nor will the completion of any college course necessarily secure its attainment because of its personal quality. Further, culture is the result of a life, and the most that can be expected of a college course is to open the students' eyes to its real worth, to start them right with certain leanings and aptitudes and furnish them with the means of a continuous growth toward its maturity.

It is maintained that an engineering course can tend in this direction and that in some of our best colleges, under the instruction of people themselves cultured, it does so tend to-day. Our best engineering courses are stiffer and more exacting both as to time and effort

than those in the college of arts and the resulting acquisition of mental power and the ability to focus it proportionately greater. The fixed course with its correlated parts and the certain definite end to be strived for are advantageous. The training is a continuous testing and trying of the truth of knowledge and teaches the student to ask "why" and to reflect. He gains respect for nature's laws and learns that his professional success will depend on his ability to work in harmony with her. He gathers a fair degree of knowledge of himself, his strong points as well as his limitations. He acquires a habit of thought and action that leads to further growth. He learns how to adapt means to an end and within what limits of precision to work that it may be reached with economy. In short he becomes a trained and educated man, cultured to a certain degree, but with limitations; just as the arts student who has specialized to a like degree in language and literature, with little of science training, becomes cultured, but also with limitations. Let the latter retain his A.B. On the other hand let it be recognized that the engineering B.S. stands for culture as well, of equal worth and value though of different kind. As between the two specialists I think the advantage lies with the engineering graduate as being on the whole better equipped for a life of useful service and one that will possess the greater capacity for further development.

As one looks forward ten or twenty years and attempts from present tendencies to forecast the work and social standing of engineers, he must see that the profession will be doing a larger work and exerting a

greater influence. Further, that an engineering training will be more and more recognized as the one best fitted to lead to positions of an executive nature in connection with industrial enterprises and in the administration of public works. Everywhere will be demanded expert skill, sound judgment and broad views, primarily because these will be found to be economical. The entire class of men that a recent writer has called "mattoids," the ill-trained, narrow and egoistic, will be pushed out because their service is costly.

There are two tendencies in the present-day engineering education that are in my judgment opposed to the desirable result. First, a tendency to crowd too much of the foundation work back upon the preparatory school, already overloaded. This Society's Committee on Entrance Requirements has advocated a standard which is high enough. Second, the allowing of technical subjects to crowd the fundamental general ones from the college course, in a vain attempt to do what from the very nature of the case can not be done, make an engineer by college study. The result of this in some institutions is further seen in too early a differentiation between the various engineering courses; so that for instance, the civil student knows nothing of applied electricity, and the electrical nothing of surveying, while neither has a chance to acquire a taste for literature.

The whole problem is an involved and complicated one, but there is a way out that must be found if the engineer is to fill the important place that awaits him. One part of the solution will be found probably in a

refining of the methods of instruction, so that better results may be reached in the same time. In the end, however, the writer thinks that there must come a deeper sense that after all life is long, that it should be taken with more of deliberation, and that it is the end that is important rather than the beginning. The feverish rush and haste to be earning must be replaced by a recognition of the real necessity for a full and rounded-out preparation if the largest and best service is to be given. Then the student will be glad to spend the one or two extra years in college that may be demanded. The wise student now will do this without its being required.

The Chief Justice of my own state has said, "The spirit of an age is that makes finally for the happiness of the race. I have absolutely no fear as to the final end of things, nor as to the steps and incidents of evolutionary development. The aspirations, the great universal passions of a people, can never move them to other ends than their highest happiness and good. The spirit of this age is commercial enterprise and conquest, and as to it I have an unspeakable conviction, that it will, as the spirits of other ages have done, work itself into forms and institutions of beauty and eternal worth to man."

It is largely through the engineer that this is to be done. The finest result requires the most skillful labor; the noblest workman demands the most fitting training.

Herein lies our responsibility!

THE ARRANGEMENT OF ELECTRICAL ENGINEERING COURSES.

BY JOHN PRICE JACKSON,
Professor of Electrical Engineering, The Pennsylvania State College, State College, Pa.

College undergraduate courses in electrical engineering may be divided roughly into three classes: First, those dealing essentially with the details of practice; second, those teaching pure theory without making applications; and third, those which teach theory with direct reference to the utilities.

A college education is ordinarily designed, primarily, to produce a suitable mental development, and, secondarily, for the instillation of knowledge and the acquisition of culture. The first class of courses in electrical engineering mentioned are apt to make the acquisition of knowledge abnormally important, that is, to fill the student's mind with a mass of detailed information or facts without due regard to the underlying causes. In other words he becomes something of an encyclopedia and is first class for the things he knows but is apt to be unable to adapt himself to the unfamiliar conditions that are continually arising in the life of an engineer. This kind of a course may develop the memory, but it certainly fails to develop the mind in a way that will properly equip a man for success in the active affairs of the present day.

The second class of courses in electrical engineering, that is, those teaching pure theory, are somewhat

more satisfactory than the former as they may furnish an opportunity for excellent mental development even though the training is not along the most suitable lines for the purposes of an electrical engineer. These courses are usually those that originated in and still remain under the control of a department of physics. As the aim of the physicist is the development of truth irrespective of the availability of that truth for the uses of man, it is but natural that engineering courses under such direction must necessarily include much study in electricity and other subjects that is entirely useless for the purposes of technical training. In fact much of the advanced electricity contained in such courses will serve the young engineers' purposes scarcely better than would a course in zoölogy. Answer to this may be made by the statement that the work is excellent mental training. So it doubtless is, but why use valuable time on such subjects when just as thorough a mental training and one of much greater service can be given along truly engineering lines. If the engineering course is not to be arranged to prepare a man properly for dealing with engineering problems he had better be advised to matriculate in a physical or mathematical course.

The third class of engineering courses is not comparable with either of the others in many respects. The acquirement of knowledge or skill is not the first aim, but is rather a result of the general scheme. Neither are the technical subjects composed of purely theoretical expositions of natural laws, but are rather the development of such laws in such a manner as will enable the student to directly apply them in en-

gineering work. This training evidently requires no less mathematical or physical ability than would be the case if the work was arranged with less attention being given to practical applications. Such a course can only be successful when the corps of instructors are thorough engineers. This corps must contain as a minimum electrical, steam, hydraulic and civil engineers, and a machine designist. Excellently equipped electrical, mechanical and hydraulic laboratories and shops are also essential. These conditions are absolutely wanting in the courses offered by many colleges of the arts where there are no engineering laboratories and the engineering instructing corps consists of the professor of physics and his assistants with possibly a professor of civil engineering. It is very regrettable that such courses are established and in operation. The prospective college boy cannot judge wisely of the real merits of the college he intends entering. He sees by the catalogues that they both give courses in electrical engineering, but he cannot see that one may be prepared to give a much more suitable training than the other. After graduation, if he made a mistake in his selection, he may be taught the truth in a very forcible and unpleasant manner. The failure of the student to select aright is no fault of his and it is a pity that the popularity of electrical engineering among young men should have so blinded some of our college authorities that they are willing to offer unsuitably equipped courses.

The amount of general culture study that should be assigned time in an engineering course has been

considered from various view points by this society, and opinions of great variance have been expressed. There is no doubt, however, but that the engineer of the present day must be a cultivated, broad-minded man, fully on a par in general training with the men of older professions. The engineer, as a class, is no longer developed from the brighter portions of the laboring element without opportunity for broad training, but rather is drawn from the educated classes. This being the case, it is almost as essential that the young electrical engineer have a strong general training as that he have a proper understanding of electricity and magnetism. It is desirable, with the present development of the preparatory schools, to require the New England College Entrance Requirements in English, three years of a modern language, and a very complete course in history before graduation. At present the best high schools give this work properly, but the young man intending to enter a technical college is apt to skip a year or two of the high school course, and by cramming, pass the college examination. If the entrance requirements of the college are not stiff in regard to these general subjects, it is essential that they be scheduled in the college course and that the technical work be curtailed an equivalent amount. Although in many cases this treatment may seem severe it will doubtless turn out the best men, which means those who will be able to rise to the more responsible positions in after-life. The tendency to weaken the general training of a professional man for the purpose of extending his special development should be strictly checked.

In addition to the general subjects already specified it is very desirable to have a course of political or sociological subjects, such as political economy, constitutional and international law, etc., extending through the Junior or Senior years. Such subjects are very necessary in the education of any man in order that he may have a fair idea of the duties of citizenship, and they are also desirable as a basis for business training. The Pennsylvania State College has for a number of years required such a course of study through the Senior year for all engineering students, and the results have proven highly satisfactory in spite of the large amount of time thereby taken from purely technical subjects. Work of this nature cannot be given satisfactorily in the preparatory school as the student's mind is not, at the high school age, sufficiently developed to properly grasp the subjects.

Having settled upon the amount of time to be given to general training, which, as explained before, depends upon the entrance requirements, and having added to this the time required for the courses in physics, chemistry and mathematics, it is merely a matter of subtraction to find how much time is left for engineering work. Colleges of low entrance requirements should have not much more than the equivalent of one year for technical subjects, and those of the highest entrance requirement about two years and one half. The mathematics of all engineering colleges should cover essentially the same ground, whether a large or small proportion is included in the entrance requirements. This condition is essentially

the same as for culture subjects. The chemistry and physics courses may well be given without reference to the work done in the preparatory school as so great a majority of these schools effect such indifferent work that in many cases it is worse than useless.

Assuming that all general work has been carefully scheduled, an amount of time ranging from one fourth to one half of the total remains for essentially technical subjects. This time may be roughly divided into three equal parts, namely: Shop work and designing; applied mechanics, hydraulics and heat engines; and applied electricity and magnetism. Such a division allows about twice as much time for what are usually called mechanical engineering subjects as is allowed to electricity; and the total time allotted to electrical engineering in the course will be from one tenth to one sixth of the whole four years.

The time given to design, steam, mechanics and hydraulics should be just as great as that scheduled in the mechanical engineering course after some of the specialized work, such as locomotives, heating and ventilating, advanced engine or pump design, etc., is deducted. In fact an excellent way in which to create an electrical engineering course would be to select some well-arranged mechanical engineering course and substitute electricity in place of the more special lines of work in the latter. The best electrical engineering courses of the present day are essentially so arranged and in the opinion of the writer give, in many cases, a better preparation for the mechanical engineer than the mechanical engineering course itself. This statement is made because the electricity of the latter

course is almost universally inadequate to the needs of the present day, while the former course includes the essential subjects of the latter and at the same time gives a requisite training in electricity.

The electricity and magnetism of the course should be of about seventy-five periods' duration, of which about one third should be assigned to the laboratory. This course should consist in a careful development by lecture, recitation and experiment of the fundamental useful laws of magnetism, electro-magnetism, electric flow and electro-chemistry. Everything in the way of theoretical deductions that may be beautiful in themselves but which are of no value in the work following, should be carefully eliminated. The time allowed is none too much to give the essential, and the essential can be made to give just as thorough a mental training as the imaginary. The importance of having the elementary electricity and magnetism thoroughly taught along the lines called for by the course is apparently little considered by some of our professors of physics, with the result that valuable time must be taken later by the engineering department in reviewing or reteaching. The elementary electricity and magnetism should properly be taught by the engineering instructors as then it would be efficiently correlated with the work to follow. Such a change would strike at old-established traditions but, nevertheless, in most cases it would work a great improvement. It is well recognized at the present time that the instructor in applied mechanics should be a well-trained engineer. Electricity should be on the same plane.

About one half of the remaining time for electrical subjects should be equally divided between the principles of direct and single-phase alternating currents and machinery, the remainder being given to polyphase currents. This course, which should be continuous from the beginning of the Junior year until graduation, forms the backbone of the work. It should be thorough and vigorous. All principles should be worked out graphically, experimentally and analytically. As in the elementary electricity, however, great care must be taken to eliminate long mathematical or experimental investigations that will not be of direct service to the engineer in after-life. Such work is no more valuable than useful training and it may prove very harmful in giving the student wrong ideas of what is of fundamental importance. The study of a synchronous motor connected to a commercial circuit requires just as much thought and is infinitely more valuable than a long investigation into the form of the electrostatic field set up by a certain form of charged conductor. The writer was surprised to see a senior electrical engineer in one of our large universities finding the leakage coefficient of a dynamo by means of a costly magnetometer. He was informed that the experiment took about two weeks and that no other method was taught. It is not necessary. to comment further upon such methods as this. Commercial or shop methods will much more than fill the time that can be allotted to electrical subjects.

Special electrical applications, such as lighting, transmission, electrometallurgy, telephones, etc., should be

inserted at the proper points. As the course itself includes most of the principles to be met in these applications, very little additional time need be spent upon them. The laboratory must be supplied so fully with alternators, induction motors, transformers, etc., that the student will become just as familiar with alternating or polyphase apparatus as he is with direct currents. It should be just as simple for him to parallel two three-phase generators as it would be to parallel two direct-current dynamos, or he should understand the operation of an alternating series arc light system as well as one using direct currents. The laboratories should also be well equipped with electro-metallurgical apparatus.

It is very desirable to put much of the work both in the class-room and laboratory in the form of practical problems. Problems require accurate and independent thinking, and at the same time give the instructor a clear insight as to the way in which the work is being understood by the students. It may be laid down as a general rule that principles studied from the text-book will never be fully appreciated unless they are fully explained by means of a set of carefully arranged explanatory problems.

In summing up, it may be said briefly that the following conditions are necessary in developing a satisfactory course in electrical engineering:

1. A full corps of mechanical, civil and electrical engineering instructors.

2. Complete wood and iron working shops, mechanical and hydraulic laboratories and electrical laboratories.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] the joint
[illegible] but as a
[illegible] standing o

[illegible] ual or ex-
[illegible] directly to

[illegible] he extend-
[illegible] of giving
[illegible] ling of the

[illegible] says peace
[illegible] amount to
[illegible] is a great

[illegible] means
[illegible] as they are
[illegible] and which
[illegible] problems
with

merely theoretical assumptions are, as a rule, apt to be very misleading.

Professor D. C. Jackson.—The speaker endorses what was said by the author as apparently the department of which his brother is the head has been organized in very much the same manner as his own department. There is one thing very distinctively true in regard to the better electrical engineering courses of the country which has not been thought of sufficiently by the men who have had charge of the arrangement and administration of the mechanical engineering courses, and that is that the majority of young engineers that are needed now for employments are broadly *industrial engineers.* Such men must have had as preparation for their professional work a thorough-going training in applied mechanics, and upon that must be added the essential principles of thermodynamics and its applications, hydraulics and its applications, surveying, the theory of structures, if possible, and finally, fairly complete courses in applied electricity. Now, such men are turned out, as a rule, only as the product of our best electrical engineering courses. I suppose perhaps there are only half a dozen courses that have been brought up to a sufficiently high degree of organization to properly come within the rule, but most of the courses are advancing very rapidly.

The mechanical engineering courses have apparently lagged behind. There ought to be little fundamental difference between mechanical engineering courses and electrical engineering courses, and what difference does exist, ought to be rather largely a

matter of electives. It ought to consist, in other words, in the electives of strictly professional studies, which are purely studies in which the foundations are applied to the methods of practice. There is a very large demand for what we may call mechanical engineers, true mechanical engineers. But what are they? They are not men who are trained in the essentially narrow specialty of the design and construction of steam engines or the design and construction of hydraulic machinery or other similar specialties, but they are men who have been trained in the essential factors relative to shop management and corporation control, or railroad operation, if you choose, from the master-mechanic's end and similar executive functions of the mechanical engineer. Such men heretofore have not been trained in the mechanical engineering courses of our colleges and these courses have consequently missed one of their great opportunities. They are apparently more inclined to improve their opportunity now and they are growing toward the demand; but the difficulty has been that in the past the mechanical engineering courses have been planned to turn out specialists in machine design or specialists in thermodynamics or anything except broadly trained industrial engineers. A specialist in machine design is born, not made; an executive is made not born, and upon the latter the engineering college can work with advantage.

The colleges are at fault in not having developed the initiative, the enterprise and the executive ability of their students, which it is very, very difficult to do. But that thing must be done in order to make the

best industrial engineers. It can be done largely by influence, by the character of the treatment of students, and by the sort of ambitions that are put into them. It can be done by the selection of the work in the course, and it seems that a course of the character laid out by the author of the paper will go as far toward bringing the proper results as anything that can be considered at the present day. The mechanical engineering courses can do just as well as the electrical engineering course outlined in the paper, if their narrow specialism is abandoned and replaced by the broader industrial training.

The teacher, however, must remember that when he tries to teach enterprise and executive ability, he may expect to receive the hardest blows (for his self-conceit and regard for his teaching) in the class-room. He may pour stimulating thoughts over his students day after day for weeks and finally find that very few of them have taken root, and he cannot help but go through that desperate depression that is best illustrated, for instance, by the depression of Dmetri Rudin, as explained by Turgeniev, who, after he had failed as a teacher, was completely a wreck. But the engineering teacher may remember this (and perhaps can pluck up courage by the remembrance) that if every stimulating thought which he presents to his students, whether it be on professional applications of theoretical principles or on the development of executive ability and enterprise, if every stimulating thought took root in every student's mind, those minds would become such overburdened cyclone centers of thought that they would be ruined, and if one

About one half of the remaining time for electrical subjects should be equally divided between the principles of direct and single-phase alternating currents and machinery, the remainder being given to polyphase currents. This course, which should be continuous from the beginning of the Junior year until graduation, forms the backbone of the work. It should be thorough and vigorous. All principles should be worked out graphically, experimentally and analytically. As in the elementary electricity, however, great care must be taken to eliminate long mathematical or experimental investigations that will not be of direct service to the engineer in after-life. Such work is no more valuable than useful training and it may prove very harmful in giving the student wrong ideas of what is of fundamental importance. The study of a synchronous motor connected to a commercial circuit requires just as much thought and is infinitely more valuable than a long investigation into the form of the electrostatic field set up by a certain form of charged conductor. The writer was surprised to see a senior electrical engineer in one of our large universities finding the leakage coefficient of a dynamo by means of a costly magnetometer. He was informed that the experiment took about two weeks and that no other method was taught. It is not necessary. to comment further upon such methods as this. Commercial or shop methods will much more than fill the time that can be allotted to electrical subjects.

Special electrical applications, such as lighting, transmission, electrometallurgy, telephones, etc., should be

inserted at the proper points. As the course itself includes most of the principles to be met in these applications, very little additional time need be spent upon them. The laboratory must be supplied so fully with alternators, induction motors, transformers, etc., that the student will become just as familiar with alternating or polyphase apparatus as he is with direct currents. It should be just as simple for him to parallel two three-phase generators as it would be to parallel two direct-current dynamos, or he should understand the operation of an alternating series arc light system as well as one using direct currents. The laboratories should also be well equipped with electro-metallurgical apparatus.

It is very desirable to put much of the work both in the class-room and laboratory in the form of practical problems. Problems require accurate and independent thinking, and at the same time give the instructor a clear insight as to the way in which the work is being understood by the students. It may be laid down as a general rule that principles studied from the text-book will never be fully appreciated unless they are fully explained by means of a set of carefully arranged explanatory problems.

In summing up, it may be said briefly that the following conditions are necessary in developing a satisfactory course in electrical engineering:

1. A full corps of mechanical, civil and electrical engineering instructors.

2. Complete wood and iron working shops, mechanical and hydraulic laboratories and electrical laboratories.

an electrical engineer or a mechanical engineer will be evolved from that course. It does not matter what his choice may be after he has completed the course, he may become either one or the other.

A NEGLECTED OPPORTUNITY IN TECHNICAL EDUCATION.

BY CHARLES F. BURGESS,
Assistant Professor of Electrical Engineering, University of Wisconsin,
Madison, Wisconsin.

In the report of your committee last year on American Industrial Education, under the heading of Supplementary Schools for Industrial Workers, the public libraries were mentioned as a channel for imparting information of scientific and technical nature to boys and young men who from choice or necessity are debarred from the higher technical or industrial schools. The general influence for good of free libraries upon the public needs no discussion to emphasize its importance; but it appears that the important part which they might play in the dissemination of engineering knowledge is not fully appreciated. It is the purpose of this paper to invite attention to an available means of increasing the efficiency in this respect and thus furthering the interests of industrial education.

Although it is one of the purposes of public libraries to supply literature best selected for the needs of readers, an examination of the lists of books of scientific and technical nature in most public libraries, and especially the smaller ones, will show how poorly this purpose has been fulfilled as regards the needs of the youth, workmen, artisans and others who wish to make a study of engineering subjects. Of the great amount of available literature which exists on such

subjects, a comparatively small portion is of real value to such readers, and it is in the separation of the good from the bad and indifferent that most librarians fail in choosing their technical books.

There is no need of attempting to force good engineering literature upon the public, as there now exists a very considerable and growing demand for the same; but what appears of real importance is the supplying of this demand by making available the best material. This can be done by giving aid in the choice of suitable books covering the natural sciences and engineering to the various purchasers of engineering books, and such aid should be given by experts who are competent to judge of the merits of the various publications. If lists of such suitable books were available, librarians would not be slow in making use of the same in adding to their libraries.

The task of classifying available engineering literature from the standpoint of value to the public libraries is a very considerable and responsible undertaking, and errors of omission and inclusion would be almost impossible to avoid however carefully the work be carried out. But a temporary list, in which corrections could be made from time to time, would be an improvement upon present conditions. Indeed, such a list of books should of necessity be modified from time to time to meet changing conditions such as are brought about by new literature and changes in public interest.

The librarian is usually handicapped in the choice of suitable books covering the field of natural science and engineering by lack of familiarity with technical

matters, and engineers who have given their assistance in such choice have had difficulty in preventing their familiarity with the subjects from warping their judgment as to the value of the books when viewed from the public and elementary standpoints. As a result, most library lists show a poor selection, either from the technical standpoint or the standpoint of the requirements of the elementary reader.

Perhaps the first factor to be taken into account in the compilation of such lists is the consideration of the various classes of readers who will make use of the books. A classification of the readers might be made along the following lines:

1. The general reader, who requires books for his own information and improvement on various lines of industry and science, and who does not care to pursue the subjects in their higher development.

2. The young people, who desire to obtain information similar to the above, but who are not old enough to make use of the books for the former class. This class might also include amateurs, who have had no previous knowledge of mathematics or other elementary studies, but who wish to prepare themselves for more advanced work.

3. Artisans, workmen, students such as are in our high schools and preparatory schools, business men, manufacturers and citizens, who wish to acquire a deeper knowledge of the subjects than is given by books of a more popular nature.

4. Engineers and others, who are able to make use to advantage of advanced engineering books.

The relative importance of these four classes might

generally be considered to be in the order given. In all public libraries the first two should not be neglected. In the public library situated in a manufacturing district where there are many workmen who wish to make use of it, the third class may be of great importance; in other places it might be unimportant. The fourth classification may be considered of minor importance, although it is very desirable, where any attempt is made to give the library any degree of completeness as a place for reference, to have typical advanced books which are recognized as standards in various lines of engineering and science.

A list of books suitable for public libraries should not deal impartially with the various lines of engineering. No attempt should be made to place on the shelves as many books on civil engineering as there are on electrical engineering, although the two branches may be considered of equal importance from the engineering standpoint. Popular interest is a factor which must be taken into account. The public demands books on any new or startling development in proportion far exceeding the importance of such development. This will explain why a hundred books on electricity are called for while only one on chemistry may be requested. The Works of Nikola Tesla, a book unsuited for the general reader is for the same reason one of the most popular books in public libraries, although it is an interesting observation that the wear comes mainly in the first part of the book.

While in some lines of engineering and science there is a surplus of available material, in other lines there appears to be very little, or almost none. This is per-

haps illustrated best by the fact that in chemistry there is a great scarcity of books designed for the general reader.

Among the principal advantages which might accrue from the compilation and distribution of such lists of approved books are the following: Aid to librarians in the selection of books, thus indirectly placing at the disposal of those interested in the promotion of engineering education a share of the large amounts of money annually donated for library purposes: Aid in acquiring technical education to persons who are unable to attend the engineering schools. Where engineering books are not available through public libraries, such a list would enable workmen, artisans and others to obtain suitable libraries of their own with a minimum expenditure of money, through ability to properly choose their books.

In carrying out this plan there would therefore be found willing co-operation on the part of the librarians who are anxious to place the most suitable books in the hands of the readers and who, from lack of familiarity with technical matters, find it difficult to evaluate the great mass of engineering literature.

Members of this Association can undoubtedly recall questions such as the following which have been put to them by their non-technical friends: "What is the best book for me to read on electricity?" or "What would you recommend on the automobile?" and it would undoubtedly be a relief to be able to refer the questioner to a list of works such as is here proposed. If the technical man could find use for such a list, imagine how much greater would be the benefit to a

librarian when such perplexing questions are propounded.

The preparation of such a list is a matter pre-eminently suited to the consideration of this Association, and I trust that it may appear desirable to appoint a committee to further consider this matter, preferably with the co-operation of some of the leading librarians.

A suitable list of technical books would be of value not only to public libraries but it would be equally important in the selection of books for the libraries in high schools and other preparatory schools in which this Association is especially interested. An examination of the books which are usually found in such collections will show the improvement which could be effected by the use of such a list. In fact it may be desirable to make a separate list for use in such schools inasmuch as their requirements are not the same as those of public libraries.

The objection might be raised to such an undertaking that it would be the assumption of too much responsibility to designate what books are desirable and to cast aside others as not worthy of attention, but the shouldering of such responsibility by those competent to judge would be far better than to allow present conditions to continue and thus leave the uninformed reader barred from a great part of the best literature on account of his inability to learn where such may be obtained.

By cultivating this field of usefulness of the public library, through giving aid in the choice of the best engineering literature, a great assistance can be given the seeker of technical formation, and by means of

such work a large share of the enormous amount of money which is annually donated for library purposes can be made to serve the purpose of furthering engineering progress.

DISCUSSION.

PROFESSOR D. C. JACKSON.—In order to arouse discussion the speaker will say that he has understood that there is one library in the country which is in an important manufacturing district in New England, where the librarian came to the conclusion that he would undertake to cultivate the technical readers, or rather the readers in applied science—the workmen in the district. As explaining his state of mind it may be suggested that the libraries are just now going through a characteristic alteration which is very much like the change which has passed over the engineering schools. It was for a long time a doubtful question whether the engineering schools could really get a hold which would place them on a thoroughly professional basis.

The librarians were almost all literary men or classically trained men and many of them had originally but little sympathy with applied science. After they had been in the library for a short time they gained that sympathy from contact with their people, provided they were good librarians, and having once gained that sympathy they began to cast around to determine how they could do the most for their readers. In the particular library mentioned, which is in a manufacturing district, the librarian started by selecting a number of the best elementary books in applied science. Having found that they were welcomed, the

working men got in the habit of going to the library and of taking out those books, and having read them through they took a class a little higher—the second class, perhaps, as Professor Burgess says—and after they had read them all through their sons and daughters, the high school scholars, began to come in and read the same books. The working men made such good use of these technical books that it is said that the body of workingmen in that district have the best knowledge of their affairs that is to be found anywhere in this country in any similar district.

Now, if one librarian can do so much, certainly a committee of this Society that would place a proper list before the country at large, and which would act in harmony with a great many librarians, would do an enormously greater good, and the speaker believes that it would be wise to appoint such a committee.

Professor J. B. Johnson.—At Washington University the librarian used to come to the speaker in the same way but he did not care to constitute himself an authority on such matters, and hence never did very much, but there is apparently a great need for some organization to take up this work and shoulder the responsibility of doing it. No one person is willing to take upon himself the responsibility of speaking for the technical professions and deciding for any librarian what technical books should be purchased.

This is believed to be the proper work for a committee, but that committee ought to take a year for it, and they should have samples of all such books sent to them. A large proportion of the books which the committee would finally recommend, would be books

with which the members of this Society are not familiar, because they are too elementary. At the same time they ought to be recommended to these librarians for the use of men who have had no technical education. The selection of such books ought to be in the hands of the most competent persons to judge of their theoretical soundness. This work is believed to be a proper one for this Society.

PROFESSOR LANDRETH.—To emphasize the importance of this matter and as an instance showing the fact that librarians are not always familiar with technical subjects, and sometimes not even with historical, the case may be cited of a large library in this state containing a good many thousand volumes, in which works on Holland Patent are carded under "Inventions."

PROFESSOR ALDRICH.—It has been the custom of the Head Librarian, Professor Sharp, of the University of Illinois, to request the heads of the engineering departments to deliver annually to the seniors in the library school a short talk with accompanying book lists on their respective lines of work. It is found to be entirely satisfactory. It has served to acquaint the coming librarians with recent engineering literature. It is an opportunity to give helpful suggestions concerning engineering books. For instance, the question would be presented: "What are the best books in electrical engineering, for a general library of ten thousand volumes?" This is an every-day, practical, off-hand question that the librarian or the head of a department should answer at any time. It has been customary to give the head librarian these

lists with notes helpful for the graduates of the library school. Senior students in this school would prepare lists of books from their knowledge of the engineering field and submit them for approval. These prospective librarians select from a large university library engineering book lists bordering on the humorous. One hesitates to name authors and titles. It could not, of course, reflect upon the training of these students. They will pick up the "A, B, C" class of books, antiquated treatises, trade literature, etc. Probably many librarians of the old school are no better able than these senior students to select suitable engineering books from a large library. It presents an unparalleled situation in engineering education. Instruction in engineering literature is not organized, it is not looked after, it is not cared for, yet it is one of the most important questions. It is in a field of education that in other subjects has been thoroughly cultivated. On entering a modern public library one finds excellent reading lists upon almost every topic in history, art, literature and some science, but not in engineering or technical subjects. The librarians come seeking information. They recognize engineering as an important and timely subject. They are approachable on this question. There is no ice to be broken. They are in sympathetic touch with the best modern productions in all other lines. They are ever anxious to aid their patrons by reading lists and references. These remarks apply also to the current engineering literature. They are ill prepared to refer inquiring students or readers to really helpful current technical literature, but well prepared with references in econ-

omics, sociology, philosophy, history and literature. This question duly considered would result in the cooperation of librarians, present and prospective. The paper presented, touches upon demands now recognized by librarians and engineering educators. There is here a field in common. Discussion can but lead to definite conclusions and helpful results.

[See Minutes of the Proceedings on page 3 for the action taken at the close of the discussion.—Editors.]

THE HOWARD HOUSTON HALL, UNIVERSITY OF PENNSYLVANIA.

BY HENRY W. SPANGLER,

Professor of Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa.

Ten years ago a club house open to all students as part of the equipment of a great university did not exist. If such a building had been thought of its value as an educational factor was not sufficiently apparent to warrant the necessary outlay.

Before the year 1894 the University of Pennsylvania, as was the case with most institutions of its class, had made practically no provision for student life outside the class-rooms. A student was expected to attend at lectures at the hours prescribed, and when these duties were fulfilled he had to go elsewhere. There were, it is true, a number of student organizations in the various departments, a few having their headquarters in the university buildings. The membership in such organizations was generally confined to one subdivision of the University. As there was no general meeting-place, and but little of interest, beyond athletic contests, to bring the students of various departments together, the student body had little in common. Those who were away from home lived at one of the numerous boarding-houses near the University, under all the disadvantages that such an existence entailed.

Among the student organizations was a branch of

the Young Men's Christian Association, the membership of which was made up largely of college men. To extend its influence it seemed desirable that there should be a house exclusively devoted to its purposes, and a committee was appointed to raise funds for the erection of such a building. This project enlisted the hearty co-operation of Provost Harrison, and on his laying before Mr. Henry H. Houston, one of the University trustees, the great need of a building in which a student could pass his leisure hours the gift of a hall was made. The name of the "Howard Houston Hall" was determined upon by the trustees, in commemoration of the son of the donor, who was a graduate of the civil engineering course in the College in the class of 1878.

The site selected for the Hall is almost an ideal one, as it is practically in the center of the working buildings of the University. Within a hundred feet of it, on the various sides, are the College, Medical Lecture Hall, Medical Laboratory, the Mechanical Building, and the University Hospital, while the Library, Chemical, Hygiene and Dental Buildings are but little farther away.

The plans adopted for the building were selected after competition, and were those prepared by two young graduates of the University, who were in hearty sympathy with the undertaking. In the execution of the work, these young men were associated with a well-known firm of architects, the result being a very satisfactory one.

The building was completed and opened on January 2, 1896, and since that time every student may

comfortably spend his leisure time on the University grounds.

The building covers a rectangle 150 by 80 feet and has three floors and basement, the high peaked roof starting at the ceiling of the second floor lending itself to excellent architectural effect in the interior.

The exterior of the building is of light gray stone worked in long flat pieces. The shape of the stone and the broad, old-fashioned pointing gives the building the appearance of being solidly built. The trimmings are of Indiana limestone, used in such a way that the heavy appearance of the stone work is relieved, and the effect is very pleasing. The windows are broad and high and in such numbers that the interior is very well lighted, the oak finish of the interior making this necessary.

Carved details are to be found only in a few shields bearing the arms of the University and the initials of the donors and the corbels supporting the hood over the doorway.

The building can be entered either from the north or south side. Terraces having stone balustrades and paved with marble tiles form broad platforms at the entrance. See figure 1.

From either entrance one passes through heavy doors into a high vestibule, wainscoted in panelled oak. Bulletin boards in the north vestibule are covered with notices of general interest to university men. From the south vestibule the Treasurer's window opens into the office.

The inner vestibule doors open directly into the reception hall. It is a room 60 by 30 feet, hand-

somely finished in oak, the tables, chairs and seats being of the same material. This is the general meet-

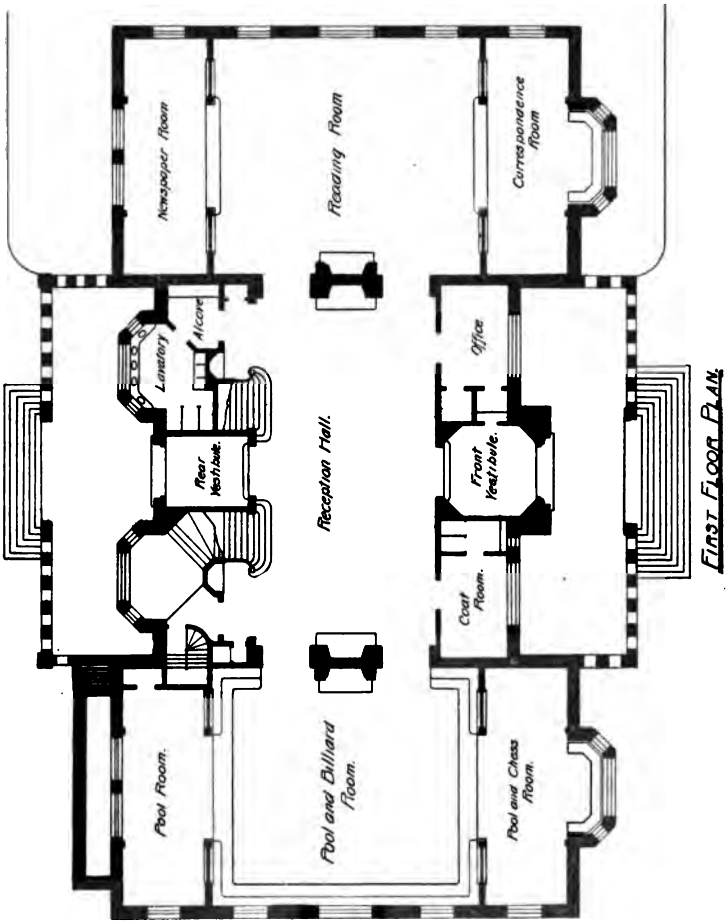


Fig. 1.

ing room, and between hours is filled with groups of students from all departments. As this is the first view one has of the interior, the beautiful furnishing,

the dim light, the bustling crowds of men, the views of the reading room and billiard room seen through the archways at the ends, impresses one with the thought that here the student is well taken care of.

At either end is a large open fireplace, and the deep leather-covered chairs put one entirely in sympathy with the motto over the lintel: "Sweet are the thoughts that savour of content."

The reading room is reached through high arched doorways on either side of the fireplace. This room is probably the most inviting one in the building. A large fireplace flanked by heavy oak pillars carrying the broad mantelpiece, the panelled oak seats in the corners, the easy chairs everywhere, the long lines of desks supplied with current periodicals, and newspapers from "home," the quiet restfulness, all tempt one to spend his quiet hours here. Current periodicals are to be found in the main room, newspapers on the raised portion at one end, and writing facilities at the other.

At the opposite end of the main hall is the billiard and pool room, having seven fine tables for billiards and pool and the raised portion of the room at one end being equipped with chess tables.

On the south front of this floor are the offices of the club and a hat and cloak room, while on the opposite side are the news stand, toilet and wash rooms.

Passing the news stand one is led directly to the basement. (See Fig. 2.) Almost at the foot of the stairs is the lunch room, the only after thought in the planning of the building. On the right is a barber shop and bowling alley, equipped with four alleys and

shuffle boards. At the opposite end is the bath and swimming pool. A marble pool having a maximum

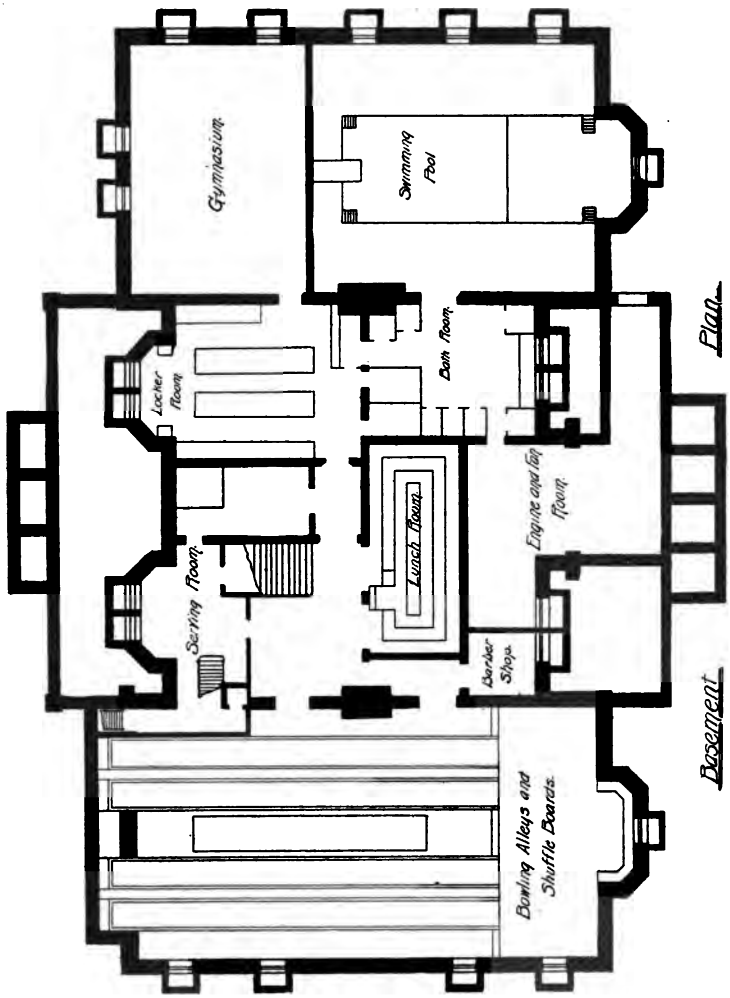


FIG. 2.

depth of ten feet and with a portion sloping from four to six feet takes up an end of the floor. A small, well-

equipped gymnasium and a locker room complete the equipment.

Going back to the reception hall, two broad stairways finished in oak, one on either side of the north entrance, lead to the floor above. The upper hall, which is about the same size as the one below, has its walls covered by excellent prints and photographs from the work of famous artists. (See Fig. 3.)

At the eastern end large doors open into the auditorium, a room large enough to hold six hundred people. It is a fine hall, finished entirely in quartered oak and has a high wainscot and heavily timbered roof. At the north end is a proscenium arch and stage, at the back of which is a large pipe organ. This hall is used for meetings, dances, and functions of all kinds during the week days and on Sundays two services are held under the direction of well-known preachers who are invited to conduct them.

At the western end of the hall is a large room used for a dining-room in connection with the main hall, and opening from this are rooms used by the Young Mens' Christian Association, the book room, the Secretary's room and the guest chamber.

The main room in front is called the trophy room. This is probably the most interesting portion of the building. Large cases contain the many trophies won by Pennsylvanians in athletic contests extending over many years. Handsome cups, banners, medals of all kinds, footballs with colors of the defeated teams and the scores, baseballs similarly adorned, fill the cases and are almost as interesting because of their beauty as from their association.

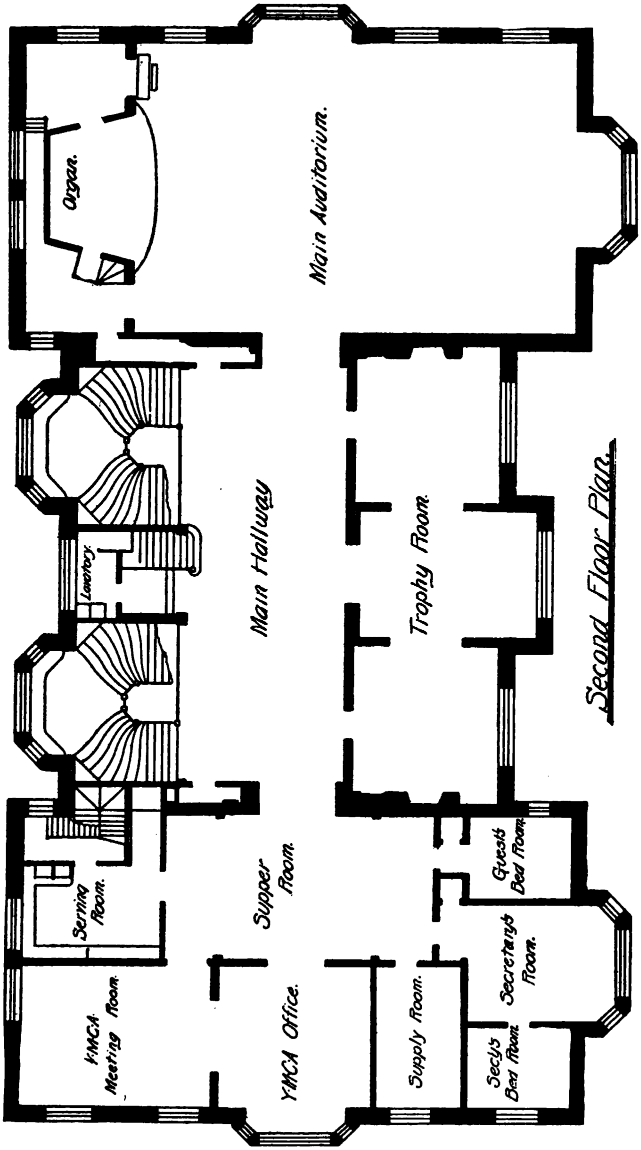

Organ.
Main Auditorium.
Main Hallway
Lavatory.
Trophy Room.
Second Floor Plan.
Serving Room.
Supper Room.
Guests Bed Room.
Secretary's Room.
Y.M.C.A. Meeting Room.
Y.M.C.A. Office.
Supply Room.
Sec'y's Bed Room.

FIG. 3.

The third floor whose plan is shown in Fig. 4 is divided into numerous offices, society and committee rooms. The University's daily *Pennsylvanian* occupies one of them. A special room is set apart for the use of the Camera Club, and in connection with it, is a well appointed and convenient dark room. The music room, which occupies the southwest angle of the third story is somewhat unlike the rest of the building in architectural character. The room suggests the old inns and dwelling houses of the Tyrol, and the heavy oak furniture carries out this idea. It is furnished in pine, which has been slightly scorched by a painter's torch before applying a transparent finish. A sombre, yet interesting, effect is produced in this way. A piano is here provided, and its tones are to be heard almost any hour in the day reverberating along the corridors and stairways of the building. There are quite a number of society rooms here also which are regularly occupied by the medical, surgical and dental societies for their regular meetings.

Up to September 1, 1896, there had been spent $153,247.66 on the building and the equipment of the hall and $2,500 on its maintenance. From September 1, 1896, to September 1, 1897, $1,190.66 additional was spent on equipment and $5,000 on maintenance, so that the total cost of the building and its equipment was $154,430.32.

It was early decided that the control of the club house should be left as much as possible in students' hands. Before the hall was completed, the Houston Club was organized and started with a membership

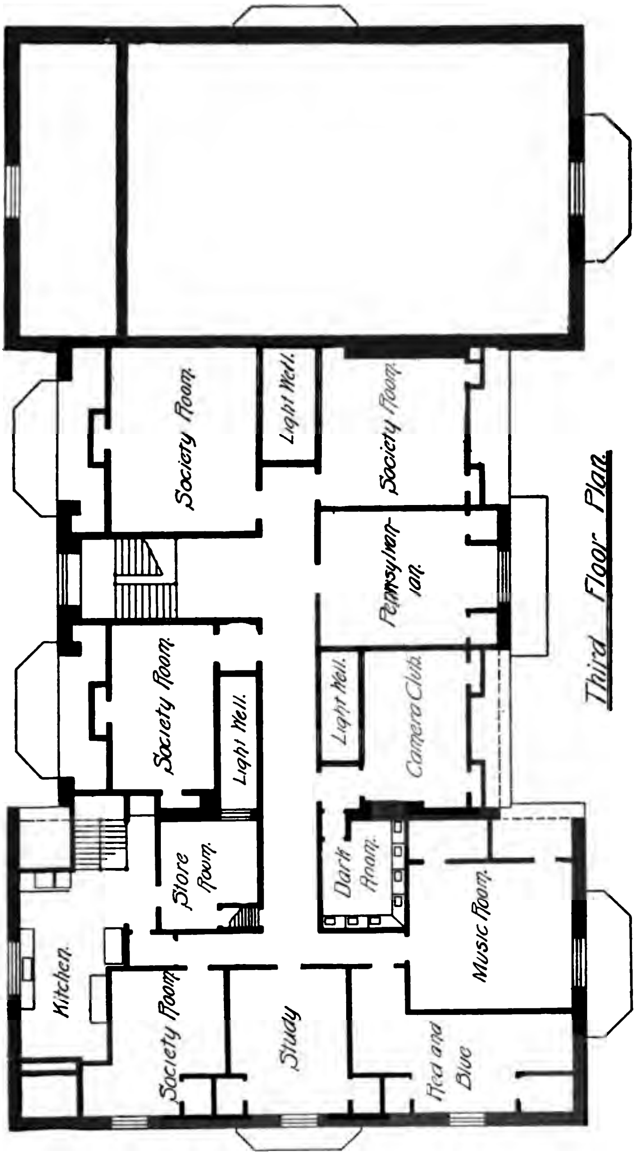

Society Room.
Light Well.
Society Room.
Pennsylvanian.
Society Room.
Light Well.
Light Well.
Camera Club.
Store Room.
Dark Room.
Music Room.
Kitchen.
Society Room.
Study.
Red and Blue.
Third Floor Plan.

FIG. 4.

of three hundred, which grew rapidly until it reached the total of fourteen hundred and fifty active or student members, and three hundred associate or alumni members.

At its first meeting an organization was perfected which resulted in the adoption of a constitution that is practically in force to-day. The details of this organization may be of interest.

Any student, alumnus, or officer of the University may become a member of the club. Honorary members are nominated by the Provost or by the Board of Directors. Life members are such as may have paid $20.00 dues. Active members must be registered students, paying dues of $2.00 per year, and these only can vote or hold office. Associate Resident Members are officers, alumni, or ex-students who have been one year at the University and have left in good standing, who live within twenty-five miles of Philadelphia, and pay dues of $2.00. Associate members are non-resident if they live over twenty-five miles from Philadelphia, and they then pay $1.00 dues. Sustaining members are those who pay $10.00 per year and have full use of bath and swimming pool, without additional expense, and they may also be classed as active members if eligible. Application for memberships are made on blanks which are posted for one week and then voted on by membership committee.

The Elective Club officers are a president, vice-president, and a recording secretary, elected for one year at the annual meeting of the club, the only restriction being that a member to be eligible to the

office of president must have been a member of the club for a year. The duties of these officers are those generally pertaining to the positions. The secretary-treasurer is an appointed officer and is selected by the board of directors.

The board of directors is composed of the deans of the various departments. This board is really the governing body of the club, but it has seldom found it necessary to interfere directly with the club management. The secretary-treasurer is the custodian of all the property and funds of the club.

The business of the club is handled by committees and sub-committees. These committees are elected, and a student in any department votes for the representatives of that department only on these committees.

The house committee contains two representatives from each department, college, philosophy, law, medical, dental and veterinary, elected as above, one member of the university faculty appointed by the board of directors, the secretary and the president; thus consisting of fifteen members.

Practically the entire control of the affairs of the club are in the hands of this committee, the financial side as well as the social.

The membership and the library committee each consists of one member from each department. The latter committee must approve all house rules relating to library.

Sub-committees of from three to five members are appointed by the house committee on pool and billiards, on bowling and on baths, and one member only

on each committee must be a member of the house committee.

It will thus be seen that only two active officers of the club are not controlled by the student body—one, the faculty member of the house committee, who is its present chairman and has held that position since the formation of the committee, and the other the secretary, who is the custodian.

The expenses of running the club are met partly from dues and partly from charges made for the use of billiard and pool tables, swimming pool, lockers, rent of rooms and Hall for various purposes, and from the return from the café and book room, etc. The following will give a fair idea of the cost of running the club house for the year from April 1, 1898, to April 1, 1899, and from 1900 to 1901.

Income.	'98–'99.	'00–'01.
Membership	$3,789.00	$3,785.30
Recreations	5,616.95	5,770.10
Other sources	2,368.13	1,305.46
News stand, profit	912.50	444.21
Café, profit	1,021.30	880.18
Book news, profit	137.85	725.00
Accounts collectable	564.68	
	$14,410.41	$12,910.25

Outgo.	'98–'99.	'00–'01.
Wages	$6,556.00	$6,873.61
Postage	136.86	131.00
Incidentals	138.49	64.43
General expenses	6,570.71	6,814.71
	$13,403.06	$13,883.75

Showing a balance of about $1,000 profit for 1898–'99, and a like deficit for 1900–'01.

The total amount of money handled each year is in the neighborhood of $30,000.

Payment for all games, etc., are by tickets only, which are sold for twenty-five cents and one dollar apiece. These tickets are good for use any time during the current college year. The prices charged are as follows: Pool, 3 cents a cue; continuous pool, 21 cents per hour per person; billiards, 24 cents a game; use of swimming pool, 6 cents; swimming pool, with soap and towel, 9 cents; tub baths, 12 cents.

There are employed in the Club 28 employees, and the service is very good.

The membership of the Club has always been large. Beginning with 300 members on the date of the opening, the number soon reached 1,500 student members and 400 associate or alumni members.

	Ending 1898.	Sept., 1899, to 1900.	1901.
Active	1,435	1,545	1,552
Associate	307	209 (resident)	310
"		17 (non-resident)	17
Sustaining	29	15	15
Life	43	48	48
	1,814	1,915	1,942

The popularity of the club is evidenced by the daily attendance, which, for the college year 1897–'98, averaged 2,100. Not less than 250 members take their noon-day meal in the café, and the room is inadequate for the demands made upon it.

During the summer months and during the University recesses the swimming pool is in constant demand, and as many as 30 people are found in it at one time.

The Wednesday evening meetings of the Christian Association are well attended and many eminent speakers address them during the year. The interest in Bible study has so increased that every department has one or more classes meeting in the rooms set apart for that purpose.

The general well-being of the club is looked after by a Ladies' Committee, which advises as to the care of the building, the quality of the food used at the café, and generally take much interest in having the club made as comfortable and healthful as possible.

The effect of the club house on the student body has been very good. The elected officers of the organization have generally realized their responsibilities and have worked together for the interests of the club. The club does not differ much from any other well-frequented social club. It has had the effect of bringing together the men of different departments in a manner impossible before, and, together with the new dormitories, has had the effect of developing a strong university community of interest.

The question will be asked as to the effect on the student individually of such opportunities. It can be answered that it is in every way good. The number of cases where the club house has been used by students to the detriment of their class work is very small, although such cases do occur, but, I believe, with much less frequency than was the case prior to the establishment of the club, when the students were obliged to go elsewhere for their amusements.

The real value to the student is not in the formation of university spirit, nor in the eliminating of the

lines of division between different departments, nor even the formation and strengthening of friendship, although all these are evident, but that he can live in a clear, wholesome atmosphere, and if he makes full use of the facilities at his hand, he can fill his leisure hours with pleasant things under conditions, which, for many, will never be met again.

Discussion.

The President.—This is an eminently appropriate subject to come before this Society since it deals with making men, and if engineers are not men first then they are not worth making. Here is a means of developing and cultivating one source of education. The educational force that there is in bringing young people themselves together is rarely realized to its full extent. Students very often learn much more from their associates than they do from their instructors, and in such an equipped building may be found a good, healthy, vigorous atmosphere for them to live in.

Professor Allen.—To what extent is the building used by members of the faculty, and how does its use by the scientific engineering faculty compare with that of the arts faculty?

Professor Spangler.—That is a question which is very difficult to answer because the hours of freedom of the professors are not always the same as those of students, but a great many professors go there almost every day, and probably as many of these are in the department of arts as in the science department. The amount of time spent there ordinarily is not very long. The speaker's practice is when eating lunch at the

university, to get his lunch in Houston Hall café, and then to go up in the reception room and sit down for an after-lunch smoke. Ordinarily one sees perhaps half a dozen of the professors or instructors of the various departments during this time. On the whole, it is used considerably by the professors, although there is a faculty club within a square of this place at which many take their luncheon.

PROFESSOR WALDO.—The paper refers to a subject which the speaker would like to hear discussed a little further, namely, the management of this building. Most college officers and teachers believe or have been led to believe that a building of this kind must be put under control of the Young Men's Christian Association in order to be a success. Otherwise various things creep in that would not be approved. That leads to two questions: In the first place, how were the funds collected for erecting the building, and, secondly, why was the Young Men's Christian Association not given control of it?

PROFESSOR SPANGLER.—Practically three $50,000.00 sums were given to the university for the erection of this building. The first one was supposed to cover all the needs of the Young Men's Christian Association but, as soon as the university authorities began to consider the matter, they saw that the question was no longer that of a small body of men but of all the university students. The result was that the board of deans, the heads of all the departments, very soon decided the trend of the proposed use of this building. The question came up for decision because there had been a considerable sum subscribed for a building for

the use of the Young Men's Christian Association before the plans were finally put in shape. The speaker thinks that the idea of not putting it in the control of the Young Men's Christian Association was entirely satisfactory and was regarded as not interfering with their rights in the matter. In fact the first president of the club was the president of the Young Men's Christian Association but it very soon got into the control of the general student body and it is not now controlled any more by one class of men than by another.

TO WHAT EXTENT SHOULD MODERN LANGUAGES BE REQUIRED IN ENGINEERING COURSES?

BY CHARLES L. CRANDALL,

Professor of Railroad Engineering and Geodesy, Cornell University, Ithaca, N. Y.

Before attempting to discuss the topic proper it may be well to inquire as to the advantages to be derived from their study. For our present purpose these may be divided into two groups:

(*a*) Training and general culture.

(*b*) Aids to professional study and to professional practice outside of the United States.

TRAINING AND GENERAL CULTURE.

The rank of modern languages among the culture studies is fairly well established, and their introduction into the high schools and preparatory schools throughout the country has become general.

Both French and German are recognized as very material aids in the study of English on account of the derivation and also on account of the facility of expression acquired in translating. Precision of thought and expression are cultivated to a much greater extent than in the study of English alone, and to as great an extent as in the study of many of the sciences.

The advantages to be derived from the critical and historical study of a language are but partially realized by the engineering student who usually takes but one or two years of any one.

AIDS TO PROFESSIONAL STUDY AND TO PROFESSIONAL PRACTICE OUTSIDE OF THE UNITED STATES.

The rank of modern languages in this group has not been so well established. Many of our most successful engineers have never studied a modern language, and many of the college and technical graduates who have, never make use of them; in fact, the rank and file of the profession, do not find, or at least do not take, the time necessary to become familiar with what is being published in English along their special lines of work.

Again, it is claimed that any article of value, or at least of general engineering interest, will soon find its way into English. From this point of view the practical benefits to be derived would not appear to be great.

On the other hand, the requirements of engineering practice are becoming more exacting year by year; an engineer does not feel competent to advise or to design along many of the most important specialties without knowing the results of the latest and best practice in other countries. This information can often be obtained only by a careful study of the original data and reports; a translation containing the points of general interest and published six months or a year after the original publication may fail to bring out the desired information, or it may appear too late to be of value in designing an important piece of work.

Engineers are constantly visiting other countries to study engineering work and to come in contact

with the men who designed and are in charge of such work.

Professors in the engineering schools, whose ranks are filled from the profession or from among the technical graduates, are also endeavoring to keep abreast of the best in engineering, in part at least, through technical literature.

The occupation of foreign territory by the United States has caused an appreciable influx of engineers to those countries to engage in engineering work. The development of the idea of expansion, due in large measure to the necessity for finding foreign markets, is forcing many of our engineers to foreign countries to look after the interests of our manufacturers and investors. A knowledge of the language of the country is essential for the greatest efficiency.

There is thus a demand for modern languages on the part of a large class of graduates, a demand strong enough to require that it be given careful consideration in planning or revising a course of study.

This brings us to the topic proper—to what extent should they be required?

The writer believes that whenever satisfactory entrance requirements can be secured, the minimum should be two years of French or of German, either required for entrance or taken in course. Two years are specified because it is believed that the average student will be unable to read engineering literature with only one year's preparation with sufficient interest and intelligence to form the habit of using the acquired language or English as most accessible in looking up material.

Two years of French should enable the average student to read readily after looking up words in the dictionary for the first few pages, so as to become familiar with the vocabulary of the author and of the subject treated.

With two years of German rather more persistence will be required on the part of the student in beginning to read technical literature: more words will have to be looked up and more involved expressions interpreted, while a greater variety of style and expression will be found among different authors.

On this account the writer believes that French will generally be of more practical value to the student unless some technical reading can be acquired in addition to or as part of the two years' course. The study of French will also be of greater aid in reading or speaking Italian, Spanish or Portuguese.

It is not felt necessary to discuss the question as to which opens up the better field of technical literature, as the difference is not great.

The discussion of the maximum amount of modern languages to be required opens up a larger field, unless it be limited to the engineering portion of the course proper.

With the increase in the number of those taking college courses, there is a growing tendency to take a general course before entering the technical course. Where the elective system prevails for the general course, the student can generally, by electing some of the work in the technical course during the first four years, succeed in completing both four-year courses in six years.

In the case of the general course it is believed that two, or even three, years each of French and German, and one of Spanish or Italian is none too much for a proper balance with the other subjects of the course.

It is believed that the above maximum is too great for the ordinary four years' course, unless a considerable portion can be required for admission, or the institution is much stronger in modern languages than in English, the sciences, mathematics, or engineering. These local conditions should be given due weight, so that the course of study will be to quite an extent an expression of the best efficiency obtainable under the conditions imposed; general principles and ideal considerations exerting only a modifying influence.

The following table, made up from the catalogues on hand at the College of Civil Engineering, may be of interest. The catalogues are all recent, but not in all cases the latest.

MODERN LANGUAGE REQUIREMENTS.

No. of Institutions.	Years for Entrance.	Years in Course.
9	0	0
3	0	1
5	0	2
1	0	3
3	1	0
8	1	1
2	1	2
2	1	2½
3	1	3
1	1	4
6	2	0
3	2	1
1	2	1½
3	2	2
1	2	3
1	3	1
52		

RECOMBINING.

9	require	none.
6	"	1 year.
19	"	2 years.
6	"	3 "
3	"	$3\frac{1}{2}$ "
7	"	4 "
2	"	5 "
52		

Two or three institutions have been counted twice, on account of having different requirements for different courses. Two or three in the above list accept Latin, in part, for entrance language.

DISCUSSION.

PROFESSOR J. B. JOHNSON.—With the increased amount of modern languages which can now be obtained from the preparatory schools, a subject which they can teach better than they can many other subjects which the technical schools require, and with the increased amount of technical work which it is felt must be crowded into the four years' course, it appears that there will be a constant demand for more modern languages for entrance, with less place provided for it in the course. Furthermore, the speaker now feels that the student should be given an option between modern languages and other subjects which are of humanitarian interest, and of importance in engineering practice. The president this morning mentioned many things which ought to be in a course in engineering in the technical schools, which we all endorse but which cannot be provided for in a four years' course. The students are being crowded

to the limit in the technical work. Most engineering teachers believe that four years is enough and that it is unwise to require five. The speaker had an experience of five or six years with a forced five-year course. There was no graduation at the end of four years. It is not wise to do that Furthermore, our work must be based upon the work of the high school, such as it is, but that work can be modified in the way of giving more of one thing and less of some other things ; as, for instance, more modern languages. The speaker has recently been impressed with the great importance of some other subjects besides modern languages which are not taught in our schools of engineering but which are taught in other departments of our large universities, subjects which in general are included under the term humanities. Some of these subjects are becoming real sciences and not simply formulated theories and opinions, and the engineering students ought to know something about them. For instance, at the University of Wisconsin, there are many courses in the new School of Commerce, such as commercial geography, history of commerce, transportation, business organization and management, banking and finance. Now, all these questions are questions which every manager of a business needs to know something about, and if the engineering graduates are to become managers and have business relations over a large part of the earth's surface, they should have broader views upon these subjects. While for any man who expects to teach engineering, or to keep abreast with the literature of engineering in his field, it is absolutely necessary that he shall read both

French and German, yet but a very small proportion of the graduates do either and the speaker thinks fully that three quarters of all the graduates of our colleges of engineering never make any appreciable practical use of their modern languages after they graduate. Now, if these views are correct, is it not unwise to spend so much of the student's time in the four-year course in the technical school upon modern language? He should have the opportunity of doing it but might not modern language be made alternative with some of these humanitarian subjects? Again, there are a good many men who find it impossible to acquire a modern language, absolutely impossible, humanly speaking, and they have been held up on graduation because they had failed in their modern language. This is the only severe pain that is left in the courses of study in engineering, and it is a pain with many a student as well as to his teachers, especially those who try to teach him the language. That is no joke. Now, the speaker hesitates to recommend to his faculty that modern language be made optional because it would throw that college into a comparatively unique class. You have heard the figures. Not a single instance was given where a modern language was optional, even after two years of it was required for entrance, which is the requirement at Madison. It is either all required for entrance, or included in the prescribed course, or it is not given at all. Now, why should not modern languages be made optional with some other humanistic or culture study, which may be of more advantage to the man who elects it than modern languages? Why

should it not be done ? The speaker wants that particular question answered because he cannot answer it.

Professor Aldrich.—Dean Johnson has well said that of all requirements for graduation those in the modern languages can be most readily met in preparatory or high schools before the work of the university is reached. In many of the states German is taught side by side with English. The most difficult language to be obtained in this way is the French. Latin is most frequently offered. There is little reason why it should not be accepted in lieu of French. In some instances, two years of foreign language are required for entrance to the engineering courses. They may consist of two years of French or German or Latin or Greek ; or one year each of any two of them, as one year of German and one year of French. It is understood that one year of any foreign language, in preparatory or high schools, is not all that a professional man ought to have. The situation should be candidly viewed. What can the student get and what can be crowded into those years ? After he enters the university there is usually the option in the freshman year of a year of French or German or English. The speaker wishes to correct Dean Johnson's statement as to foreign language being required for graduation. At the University of Illinois it is not so required if the student has satisfied the entrance requirement of two years of foreign languages.

Mr. Kent.—The humanistic studies mentioned by Professor Johnson should not be put in the same grade nor considered as satisfactory electives to take

the place of the languages. The study of a foreign language requires intense concentration of the mind and it is of value not so much from the acquirement of the languages as from the mental training it gives the student while he acquires it. The humanistic studies are those that will be taken up by any man in after life. All who are present here are doubtless to-day studying sociology; it is being rubbed in by the newspapers and magazines and books and in other ways. These humanistic studies are not a necessary equipment of a college graduate, but any intelligent graduate will acquire them to some extent after graduation; but he will not acquire languages unless he is compelled to do the work right under the direction of a teacher. The speaker has been watching one boy's course very carefully and has observed that Latin was the first thing in this student's course that made him get right down to hard study. He had to study hard when he got to Latin, and he never studied hard before. After he had one and a half year's of Latin his mind was so trained that he could concentrate it on mathematics, hence the Latin language was very important to him, not for the acquirement of any facility of handling it as he will probably forget all he ever learned. The French and German and Spanish have all been of benefit to him in forcing him to study, but these humanistic studies can be read by anybody easily and they do not require that concentration of mind that the other studies do. Banking and finance and the commercial studies may be acquired in after life and hence he does not need to get them in college. It would be advisable if he could, but language should

not be turned out for the purpose of taking some of the other things.

PROFESSOR NAGLE.—There is one objection to the suggestion made by Professor Johnson, and that is the inability of the student, at the time he would have to elect between two or more subjects, to choose judiciously. In the speaker's own case he was a full-grown man, and the engineering course required both French and German, and yet he very nearly sacrificed the course as laid out because he had to take the French. He objected to it, and didn't want it, but he has found since that he had more use for that than any other of the three languages taken. That objection inheres in any elective system. The studen- does not know what is going to be useful to him and he does not know how to select judiciously. Some languages ought to be taught—perhaps one might suffice—if for nothing more than to open up to the student the possibilities of further study in that language. The speaker would not like to see Professor Johnson's suggestion carried out completely, although in many cases it might work satisfactorily.

PROFESSOR WALDO.—Attention is called to the wording of the subject which we are discussing: "To what extent should modern languages be required in engineering courses?" The probable meaning is, to what extent must modern languages be absolutely required for graduation? Shall young men be graduated in our engineering courses who have had no modern language or must modern language always be an element?

The speaker remembers a young man of rather

strong parts, who worked long and unceasingly upon his German, tried and tried again and failed utterly, and finally had to give up his course in engineering simply because he could not master his German. That was one of the absolute requirements in the institution which he was then attending and it seemed to be a hardship for that young man. He could do his mathematics; he could understand engineering subjects; he had a future before him which was full of usefulness if he had been allowed to go on. His spirit was broken. As it was, he was obliged to give up his engineering ambitions. He abandoned further struggle for a higher education, and since that time he has amounted to very little. Such cases are not seldom found. Is it right to cut off a young man from a useful career by some non-essential requirement of this kind? No one will deny that modern language is very desirable. Should it be absolute?

A suggestion in another direction seems pertinent to the discussion. Of all institutions, engineering schools should quickest react to the stimulus of popular demand and present opportunity. In view then of the possibilities of services which "expansion" presents to the young engineer, why do not these schools give more and better instruction in Spanish?

Professor Esty.—On the programme the title is "To what extent should modern languages be required," and the word "foreign" is not present. One may therefore suppose himself within bounds if he should regard English as one of those languages. The discussion of some of the previous speakers seems to have been based on the assumption that the foreign

languages only are implied. Although not knowing the intention of the author, as expressed in the title of the paper, the speaker wishes to bring one phase of this matter before the society that has appealed to him, perhaps because he has had two kinds of college courses himself. He had the B.A. course followed by an engineering course, and hence is prone to make comparisons between the studies as given in the two courses. The speaker's observation leads him to the conclusion that engineering students as a whole are less fitted by nature or by their particular mind-structure for acquiring foreign languages. He has seen a great many bright engineering students, such as the one mentioned by Professor Waldo, who were good at mathematics and who took kindly to engineering subjects but who, on a lesson in French or German, would make a perfect failure.

However, the speaker is not quite sure that Professor Waldo's conclusion is correct one, that because a certain class of students or a number of individuals in engineering find modern languages difficult, they ought to be abolished. To make them even broadly elective, seems inadvisable as there is a great advantage for any student to be more or less compelled to learn something that he does not take kindly to by nature. It shows that there is a defect somewhere; although it may not be his fault. Nevertheless, if that is his line of maximum resistance, it shows that there is a weak element that ought to be developed. In the so-called literary and classical courses in college, one often finds that the men who do the best in languages are the poorest in mathematics. Some

teachers have said that they thought it was good for a man if he had the nerve to deliberately elect mathematics when he knew he was poor in mathematics, in order to develop that weak side of his intellect, and for the same reason most of our engineering students ought to have a good reading knowledge of one of the modern foreign languages.

Sometimes a mistake is made in discussing this question, French and German being lumped off together and made equivalent one to the other. The speaker's experience is that German requires almost double the time of French. If only one year be available in the engineering schools for a modern foreign language, it may be regarded as almost hopeless to precribe German for that one year; let French or Spanish be taken in such a case.

Professor Nagle.—Coming from the neighborhood of the Mexican border, having been across the border and worked a little while in Mexico, and having studied Spanish previous to having gone there, the speaker questions the advisability of studying Spanish rather than either French or German in an engineering college course. It was found, after having taken Spanish something over a year, and previous to that having had some knowledge of the pronunciation as the common laborers use it, from having employed them, that on going into Mexico about the only thing the speaker could say was "Good morning" or "Good day." But after remaining there only ten weeks, taking a little interest in the grammar and attempting to speak it whenever possible, or to acquire the vernacular, he was able to get along very well. The speaker

learned more in those ten weeks than he would have done in three years of study, as regards the spoken language, and found that his knowledge of French aided him materially in this. The Spanish engineering literature is very, very poor, and there is very little of it, and hence it would not be advisable to put in Spanish as a culture language against either French or German.

PROFESSOR D. C. JACKSON.—It is believed that all members of the society look pretty closely to the technical and professional value of the studies that are in the engineering courses, but it is often forgotten that it is the teacher's business to look also to their pedagogical value. The speaker is a believer in language study for two reasons. First, the study of language is desirable for the training it gives; and second, the knowledge of language is desirable for the satisfaction and power it lends to its owner. I refer not merely to English but to the foreign languages in addition, including the classical languages. The speaker does not care for Greek but he thinks Latin is worth having. A good professional engineer is a man who has a satisfaction in his own attainments in other lines besides those of purely professional acquirement and he gains power from them.

But it must be remembered that it is good pedagogy to teach languages to the youngsters, and consequently it should be aimed to get as much of the language teaching as possible into the subordinate schools. If we cannot require more than two years of foreign language and some English to be taught in the subordinate schools, then we must see to it that some

foreign language, and considerable English, shall be taught in the engineering courses. If, however, the subordinate schools can be induced to teach their English well, and teach French for two or three years and Latin either two or three years, or German and an equal amount of Latin, then every bit of language may be omitted from the engineering courses with gladness. But until the subordinate schools can be brought to this happy pass, it is not believed to be justifiable to forego all language instruction in the engineering courses. We should gladly forego the language now taught in the engineering courses, if the subordinate schools would teach it properly, because that would be good pedagogy. The present practice runs counter to pedagogical methods of the best kind.

On the other hand. The speaker would be very willing to omit the biology, for instance which is taught in the subordinate schools. Within a few weeks he has read the best text-book on biology which is used in those schools, and finds that biological science is set forth therein as a strictly descriptive science, and hence as mind training it is the most useless science that can be taught in subordinate schools.

PROFESSOR J. B. JOHNSON.—Don't they study it altogether in connection with laboratory work?

PROFESSOR D. C. JACKSON.—They have laboratory work, of course, but in the large proportion of high schools the laboratories are not properly equipped.

The subordinate schools should be encouraged and helped along in their language teaching. The teacher of engineering can do a great deal to help them along;

they can bring pressure on them that may help them along, and they can help in many other ways. In Wisconsin, pressure cannot be brought directly upon the preparatory or fitting schools as in some of the eastern states, but it must be done through the committee on accredited schools and the superintendent of public instruction. This makes the work a little harder, but good progress is being made in Wisconsin and finally there will be a magnificent course in the high schools.

There is one other thing that was mentioned by Professor Johnson. The speaker would have more faith in the commercial courses including work on transportation and the organization of industries and industrial history, if the subjects were taught by experts on transportation or on industrial organization and industrial history instead of by young men who have only studied the text-books, though they may have done that thoroughly. These men may know the literature down to a dot, but they have seen the industries themselves only from the outside, and hence cannot really know them. The engineers can teach transportation and industrial organization in a better manner if they will undertake it. Men who have had professional engineering training can teach those subjects in far better manner than it can be done in the average college of commerce which is now in existence; and until the colleges of commerce can come to fully recognize the situation, the colleges of engineering cannot afford to turn their men who are being trained for industrial work over to such superficial courses.

Professor Emory.—The real question is to what extent shall these modern languages be introduced in our colleges. The speaker has been discussing this with the professors of French and German at Morgantown. The professor of German is of the opinion that with a carefully arranged course he can meet the requirements of the engineering student in scientific German in two years. And it is very generally agreed that a student can read good scientific French after a year and a half or two years of study provided that the courses are specially arranged for the engineering student.

Professor Magruder.—There seem to be three reasons, the intellectual, the professional and the commercial, why language studies should be included in our engineering courses. Professor Jackson has mentioned two of them; they are, first, a study of linguistics in order that the mind of the student shall be trained in language work; second, as a means to enable him to read modern languages and so keep abreast of the times by learning directly what his engineering brethren are doing in other countries; and third, to enable the engineer to enter into commercial relations with foreigners or to go into our foreign possessions and when he gets there to find that he is able to say something more than "good morning" and "how do you do." It is believed that a mistake has been made in cutting down the amount of work required in foreign languages in the curriculum and permitting a choice between French and German. When a student has a chance to decide for himself, without any expert advice, he usually inquires,

"which is the easier? with which can one get through with the least labor?" and someone says "French"; whereupon he elects French. Personal experience indicates, however, that if he asks the advice of any of his instructors, they will say, "take German." Why? Because German is needed more in order that the student shall be able to read technical engineering literature when that literature is in a foreign language. In Ohio State University, where electives are permitted for the other courses, two full years of German are absolutely required in chemistry.

The speaker also thinks that a mistake was made in making Spanish an equivalent of French as was done in some cases; and also recently in making it the equivalent of French or German. It is doubtful if any teacher of modern languages would maintain that Spanish is the equivalent of either of the others, as a training in linguistics; and we engineers know that it has no engineering literature, so that it would seem that its recent introduction into engineering courses is but a step in our commercial expansion as a nation. We engineering educators should be careful lest we permit the third reason for the study of modern languages to dominate the two more important ones.

HOW THE GRADUATION THESIS CAN BE MADE MOST EFFECTIVE IN COLLEGE TRAINING.

BY WILLIAM M. TOWLE,

Assistant Professor of Practical Mechanics, Pennsylvania State College, State College, Pa.

The object of college training should be to prepare the student in the best possible manner for the active affairs of life. To do this he must learn to think and reason for himself. To get him to do this is the greatest problem that confronts the educator. The student finds that there are many things that he has to learn that he does not fully understand. He should be taught to look for the reason for each step and encouraged and required to master each principle involved, thereby making it available for future use.

We take up this problem, "How the Graduation Thesis can be Made Most Effective in College Training," from an engineering point of view, but I think the same principles will hold good in any branch of education.

By the work in the engineering seminary, journal reviews, inspection trips, reports and discussion of these trips, etc., during the junior and senior years the student should have been made familiar with some of the professional work of masters in the active affairs of public and commercial life. If his mind has been trained by previous work to think and reason he has looked into some of these problems to find out why they were done that way and he has found that

practical as well as theoretical conditions have influenced the work. By studying how these problems have been solved and difficult conditions overcome he ought to be prepared to take up a subject and consider it in, at least, the most important of its relations to both theory and practice.

The time in a four years' course with the present entrance requirements is too short to give much professional training, but the teaching and work of the senior year should always have this in view. The graduation thesis work should be conducted on the plan of making it as nearly like professional and commercial work as possible, thus fitting the student for his next step in life by teaching him method, order and responsibility.

For the graduation thesis, let the student take, if possible, a subject in the line of work he expects to follow as this will give him a fund of information that will be useful besides the training from the thesis work and it will appeal to him to put forth an extra effort to do good work.

It is suggested that towards the close of the junior year the heads of departments give a talk to their classes on this subject, explaining the method and manner of thesis work and what is expected of them for a thesis, and strongly urge them to choose a subject, so that some thought, reading and observation can be put upon it during the summer vacation. Soon after the opening of the senior year let the student be required to present the subject and the proposed method of treatment for approval.

When considering the subject with the student the

instructor should act as a consulting or chief engineer and not as an originator. He should require a clear statement of what is proposed to be done, approving, criticizing or suggesting, as the case may demand, and only indicating where information and help can be found.

As the thesis is supposed to be a test of what his education and training have done for him, after this preliminary work let the student depend upon himself almost wholly so that he will feel the responsibility for the work. He should be permitted to consult the instructor to a certain extent, the instructor acting as a critic. By such criticism and suggestion this work can be made very effective in emphasizing the principles that have been brought out in the studies, and their application can be made to the work in hand.

If the subject is such that it requires new or special apparatus to be designed or constructed require complete drawings and specifications to be made as soon as possible. Have the student make bills of material and orders for work and supplies the same as in commercial life. Have him keep an account of all material and work so that he can give the exact cost, for it is just as important to know the cost of an experiment as of a marketable product.

If the thesis be an original design, project or investigation let all the influencing conditions or factors be ascertained or assumed, then by reading, study and observation, find out what has been accomplished in this line and what is desired. Then with the conditions actual or imposed proceed to work out the best

possible solution, always keeping both efficiency and cost in view, analyzing each step and giving a reason therefor.

If the thesis is a review of some noted piece of work, require as complete a statement of the conditions that influence the design as is possible to obtain, then a study of how it was worked out, giving the apparent reasons.

If anything unusual happened during the progress of the work and the details can be obtained have this factor taken into consideration. A noted inventor said "a good foresight is an excellent thing but a good hindsight is worth something if we make it serve us in the future." We ought to learn something from the experiences of others.

If the thesis is the test of the efficiency of a machine, plant or something of a similar character, require that the investigations go deeper into the subject than the present efficiency or cost. Have the student consider whether the design and conditions under which it is working are the best possible.

If from his studies and observations he thinks the conditions could be bettered let him suggest improvements, supporting his suggestions by theory and recorded experience as far as possible.

Such theoretical and practical treatment must stimulate thought and originality in investigation and design, thereby making the thesis work of maximum efficiency.

Discussion.

Professor Rice (by letter).—It seems that one important consideration relating to theses is to keep the

problem involved of sufficient simplicity so that the student can, in the time available, fully complete his work, and leave it with a sense of having accomplished that which he set out to do. Many times the subject taken is too large to be properly considered in the time available or the difficulties encountered are too great to be overcome by the student, and the work has to be wound up in an incomplete state or results accepted which are unsatisfactory to both student and teacher.

In a business house the student would be entrusted with only simple details unless the time which he could have for the completion of a job were unlimited. Why should a different policy be adopted in the college course? Is it not better for the student, for the teacher and for the institution to have the theses of such simple character that the work, when left by the student is complete and finished so far as he has undertaken it than to have it ended up hurriedly, leaving the whole matter incomplete, because the student has undertaken something too big or too extensive for him?

Professor J. P. Jackson.—Professor Towle has put the matter very clearly and, without question, has stated the proper methods if good results are to be obtained. The graduation thesis affords an opportunity more than any other subject, where the student may learn to be independent and self-reliant. When he takes hold of a switch or a throttle in this work he knows that he must do so on his own responsibility and this is what he has to do when he gets out of college. In thesis construction work he must have the

nerve to apply his ability. Many students lack in that independent nerve. They will do exactly what they are told, but if they are told to do something requiring independent decision they fail and here is the most difficult thing to handle in arranging the graduation thesis. The student wants to come to his professor and ask him how he should do this, or how he should do that. To overcome this serious difficulty it is an exceedingly desirable thing to start independent investigation, even as early as the beginning of the junior year (something in the way of a term thesis). Let the student take such early work and begin to be independent. He has done independent work in the laboratory, to a certain extent, but he thinks the professors are perfect and that anything they say is right, and he thinks also that anything that the text-book says is almost equal to an inspiration. It is with the greatest difficulty that one can persuade a student that a professor or a text-book should be used merely to enable him to assure himself of the truth.

By giving an independent thesis two or three times during the junior year and making the student work it out, watching him only as far as it is necessary to prevent too much injury to laboratory instruments, he may be put upon a fair way to go on with his graduation thesis. Let him destroy a few instruments and mend them if he can; burn out two or three dynamos; and break up two or three engines if it is necessary. Let him follow the curriculum that Professor Towle has laid down, see that he does not waste time, give him a little direction here and there where he is going in wrong lines, but make it

his work and when he is through, that work will probably be of more direct importance to him in teaching him the quality of self-dependence than any other feature of his whole four years' course.

Professor Allen.—It is very agreeable to find that the paper and the discussion seem to be pretty uniformly agreed that the thesis should do as much as possible for the student so that it is somewhat encouraging to believe that the practice has grown to a considerable extent at least, away from the idea that the thesis is principally a special form of examination. To the speaker's mind the thesis should serve its purpose as a part of the work of instruction, and the discussion to-day has been with a recognition of that view, which is believed to be the correct one. While it may be entirely proper that the thesis as well as all the other work should serve in part as a measure of the student's ability, yet the work that the college does should be mainly work of instruction and the thesis should be definitely an instrument of instruction.

Mr. A. J. Wood.—The speaker questioned if a student would gain the greatest benefit possible from thesis work which was so simple in its requirements that there would be no incentive to continue investigations along the same or similar lines after leaving college. It seemed to him that the suggestion which had been made, that a simple or "easy" subject be assigned, might not accomplish what was most desired in this class of work. If proper care be taken in the selection of a subject and if the student be left largely to his own devices, the thesis may serve not only to develop original methods of investigation, but may

also lead to future work along the same line, which in some instances determines the nature of his life work.

A careful examination was made of a number of theses at two technical schools for the purpose of determining just what original work had been done on three subjects. At one of the schools the thesis was purely a laboratory experiment, with fixed hours and specific directions given to the students. At the other institution, however, much freedom was given and originality was strongly encouraged. The effect of the two methods on the students as shown by their work made it evident that in the theses examined, more clear, accurate thinking was done where the investigators were left largely to their own resources. While it might not always prove the wisest course, the speaker believed that in general much more would be accomplished by permitting the student to select a subject with a pretty broad outlook and something which would stimulate his best efforts than by assigning an unimportant topic, which could be completely investigated in every particular in the required time.

THE AVAILABILITY OF CORRESPONDENCE SCHOOLS AS TRADE SCHOOLS.

BY DUGALD C. JACKSON,

Professor of Electrical Engineering, University of Wisconsin, Madison, Wis.

This paper reviews a report on the Trade Education of Central Station Employees which was made to the Northwestern Electrical Association by a committee of which the writer was chairman. The deductions of the committee apply equally as well to other trades attempted to be taught by the correspondence schools as to the trades involved in the operation of electric central stations. Among other characteristic propositions, the committee particularly considered the three following enquiries—giving special consideration, on account of the purpose of their appointment, to the conditions in electric central stations.

1. Can correspondence instruction be relied upon to increase the usefulness of employees to their employers?

2. Are existing courses of correspondence schools properly adapted to be of the greatest use to employees and through them to their employers?

3. What provisions may employers reasonably supply for the purpose of encouraging their employees to study the requirements of their business and how may those provisions be executed?

Five schools which advertise correspondence courses that enter the field of the committee were considered. These are:

The American School of Correspondence, Boston, Mass.

The Electrical Engineer Institute of Correspondence Instruction, New York City.

The International Correspondence Schools, Scranton, Pa.

The National Correspondence Institute, Washington, D. C.

The United Correspondence Schools, New York City.

The fourth one on the list (the National Correspondence Institute) informed the committee by letter that it presents no courses which fall within the province of the committee's investigation.

Each of the other schools has an aggregate enrollment in all of its courses which reaches into the thousands. One school, The International, advertises an aggregate total enrollment of over two hundred thousand. This aggregate, however, must be understood as representing the total enrollments which the school has enjoyed since its organization, but even thus considered the number is large enough to be amazing. The enrollments of the other schools are smaller than this, but they are in each case large enough to provoke consideration for their work. The courses of the Electrical Engineer Institute of Correspondence Instruction deals only with applied electricity and allied technical branches.

The capital invested in the different schools is large. The International Schools, which is an incorporated concern in Pennsylvania, has a capital of a million and a half of dollars and the character of its buildings

and equipment makes it clearly evident that several hundred thousand dollars are invested in fixed property, while the cost of operating the school must absorb a considerable proportion of the remainder of the capital.

The United Correspondence Schools, which is incorporated in New York, has a capital stock of two hundred and fifty thousand dollars. An inspection of the headquarters of this school makes it evident that a considerable sum is invested in fixed equipment or is required in handling the business of the school.

The American School of Correspondence is incorporated under the laws of the State of Massachusetts and the Electrical Engineer Institute of Correspondence Instruction is incorporated under the laws of the State of New York. Neither of these institutions advertises its capital stock, but it appears from an inspection that the money invested in these schools is not so extensive as that invested in the others. This must not be understood to be an unfavorable criticism. It cannot be said that the moneys invested in the buildings or equipment in the other schools are essential to the best success of their efforts to teach, though they might readily be made contributary thereto.

We were dependent to a considerable extent upon the correspondence schools themselves in the effort to get information with respect to the schools, and considerable time and money was expended in interviewing the managers at the principal or local headquarters of the several schools and making personal examinations of the arrangements for dispatching business.

All of the schools courteously responded to requests

for information and all of them, with one exception, gave fairly complete information upon points enquired about. The exceptional school courteously declined to lay bare its methods of business management and the results attained by its school. The management of one school responded faithfully to the requests for information but were unwilling to allow correspondence to be carried on with its scholars except through the home office.

In arriving at a conclusion in respect to the first query set forth above we carried on a considerable correspondence with various scholars of two of the schools and received through the principal office of the third school answers to a series of questions which the scholars wrote out in reply to a request. A universal feeling amongst the subscribers of the schools, of either reasonable or enthusiastic satisfaction with the courses pursued, the methods of instruction, and the results accruing in the way of bettered situations, was brought to light by this correspondence. The scholars were almost universally from classes of society to whom a common school education above the grammar grade has been an impossibility, but in a few cases correspondence was carried on with men who can be properly classed as educated and skilled workmen.

On the whole, this correspondence confirmed the expectations which may be reasonably gained through abstract reasoning on the advantages of a special education for skilled employees or for apprentices who are expected to become skilled workmen. But it must be remembered that only a small proportion of

the committee's correspondence was carried on with such men.

An illustration of such reasoning pertains to the affairs of electric generating stations and distributing circuits where the work requires skilled labor and is of such a nature that inefficient employees may cause wastes of greater or less magnitude in almost every operation, from the stoking of the furnaces to the testing of the meters. Not the least proportion of the losses in a central station are to be laid to inferior work in the boiler room. A fireman who has been well informed in regard to the combustion of the fuel and the relation between fuel consumption and admission of air to the furnaces, may every week save a sum comparable to his wages as compared with an uninformed or careless fireman. Each fireman with a hand shovel may handle coal which has a value exceeding many times his wages. The difference between judicious and injudicious handling of this coal makes a marked difference in the earnings of a station.

A properly planned correspondence course may put the fireman upon a proper footing with respect to his handling of the coal. The engine runner, the dynamo tender, and the machinery oiler may each likewise be made more efficient through a proper understanding of his business, with a resulting considerable increase in the net earnings of a station. It is particularly important that the chief operating engineer of a station and the superintendent of the company shall be well trained in matters relating to the economical combustion of fuel for the raising of steam, the eco-

nomical operation of steam engines and auxiliaries, as well as the economical handling of electric machinery and devices, and that they shall be competent to properly instruct all of the station employees.

In all of these matters and many more, properly planned and administered correspondence courses may be relied upon to increase the usefulness of employees. The experience of the gas light companies may be looked upon as a precedent. Correspondence instruction of employees has been of such value to these companies that various corporation members of the American Gas Light Association contribute liberal sums to a fund called the "Gas Educational Fund" which is used in carrying on correspondence courses for specially designated employees of the contributors.

Correspondence instruction alone, however, cannot be relied upon to bring the greatest results, but to it must be added practical demonstrations of the proper methods of handicraft. These supplementary demonstrations may be conveniently supplied by the correspondence schools themselves for some trades, as is proved by the marked success of the instruction of railroad train hands by one of the correspondence schools through correspondence instruction which is supplemented by the liberal use of well equipped "instruction cars" for practical demonstrations. The same school has also fitted up in the local headquarters at Chicago and elsewhere very complete demonstration equipments for additional air brake instruction and special instruction in other features of train running.

A demonstration car cannot be so readily brought

to the employees in most trades, nor can the employees in most trades be so readily brought to the local headquarters of a correspondence school. Consequently, some other plan must be devised. A practicable plan is to depend on the State (whose welfare and wealth depends upon industrial progress) to establish special trades schools for the several trades. Complete trades courses may be obtained in these trades schools by those who live in the immediate vicinity or who are able to remain in the vicinity for a considerable period, and in addition thereto correspondence scholars may here obtain the requisite practical demonstrations that are essential in their trades.

In another practicable plan, the existing engineering colleges may enter to a certain degree the field of the trades schools. Much of the laboratory apparatus and appliances used in the professional engineering courses may be readily adapted to trades instruction, to which purpose it may be put for a few weeks at a time in the summer or other periods when it is not under requisition for the professional work. By a proper arrangement of this equipment, it may be brought into use for trades instruction under the conditions named without in any way trespassing upon its use in its regular service in the professional engineering courses. This is the plan that is now being uniquely tried at the University of Wisconsin, in the Summer School for Artisans and Apprentices. It is an experiment, but one which is bound to succeed. In the plan adopted at Wisconsin under the direction of Dean J. B. Johnson, it is proposed to give instruction to all comers in the scientific applications per-

taining to various trades, and it is presumed that many subscribers to the correspondence schools will embrace this opportunity to round out the character of the instruction which they are receiving. The approval of the plan by certain of the correspondence schools places them in a favorable light.

The trade instruction of the correspondence schools as it now exists is at fault in another direction. The books of several schools are well written and reasonably accurate and up-to-date, but the courses should contain much less of design and of matters verging on professional engineering and much more of the trades details before they may be of the greatest usefulness to skilled workmen and apprentices. It, again, justly creates a favorable impression of the correspondence schools that they themselves appreciate the conditions, and are doing much work to improve their courses in the direction here outlined.

The results of the careful study of the situation by the committee may be briefly epitomized as follows: The idea of correspondence instruction in the trades as they are situated in this country is an excellent one, and good is coming from the correspondence schools. The administrative methods of the schools, as far as the treatment of enrolled scholars is concerned, are good, as a rule; but the sensational methods resorted to in advertising, and the jealousy of the schools for each other, are to be deplored. It is not easy to inspire to study by correspondence, but valuable instruction in facts, which is exactly what is required in trades instruction, may be given. To make this most useful, however, auxiliary physical demon-

strations must be added to the correspondence instruction in a manner analogous to that in which demonstrations are made to railroad trainmen through traveling instruction cars, which carry complete outfits of air-brakes or other train devices.

The experience of many railroads, gas companies, electric light companies and other industrial concerns all goes to substantiate the natural inference that proper instruction may be relied upon to increase the usefulness of skilled employees, and that this increase of usefulness will result in advantage to both employed and employers. There is a demand for such *proper* instruction which has not been filled. The correspondence schools have tried to fill it and have done good. After their courses of instruction are more closely adjusted to the requirements they will do more good, but to their correspondence instruction must be added practical demonstrations in handicraftsmanship before their courses can reasonably fulfill the demand for trades instruction. And, however much the correspondence schools may do, there will still be a large opportunity to be filled by fixed trades schools in all large communities.

It must be remembered, also, that the engineering schools have no organic connection with the sphere of the trades schools, and that the two spheres are so little in contact that there is no necessity for affiliation between them, but that the faculties of the engineering schools can do much to guide trades education in the right direction by the mere weight of influence and suggestion.

DISCUSSION.

PROFESSOR ALLEN.—It is somewhat interesting to learn that the correspondence schools are to some extent finding it desirable or necessary to include what may be called laboratory work with their other method of instruction. This probably means simply that they have to provide instruction for a special class of people and they are finding in some places that the education needed is not in all cases correspondence instruction, but is in some cases laboratory instruction, as in the case of the air-brake plants. The speaker does not think that they should be adversely criticised on that account, but rather the contrary. They are working out some good in a different field from that cultivated by the engineering colleges. In relation to the trade school the speaker's impression now is that it is probably best to keep the trade school and the engineering school well divorced. It is true of many of the colleges in the country that there has been a tendency toward the separation of college work proper, even though not of a very high grade, from the work of preparatory schools. That is, there are many of the smaller colleges which have once had united with their general field of instruction the work of preparatory schools, but which later have given up the preparatory work. It seems that this possibly is an indication that it is best for the engineering colleges to expend their energy in a more limited direction and not to reach out into fields largely those of trade school work and so perhaps spread out so thin that their best energies will not be applied in the right place. It may be wise possibly to keep this in mind.

MR. KENT.—When Ezra Cornell founded Cornell University he said "I would found an institution where anyone can find instruction in any study," and when the Morrill Land Grant Act was passed in 1861 for the endowment of colleges, it was for colleges of agriculture and the mechanic arts. Now the colleges of agriculture and mechanic arts have become professional engineering colleges and are very slightly devoted to agriculture and very slightly to the mechanic arts. This development of the professional school from the trades school, as Professor Allen suggests, is contrary to the ideas of the founders of these schools. It is contrary to the genius of our age and ought not to be encouraged. There ought to be a greater harmony between the trade schools and the professional schools.

I had occasion recently to look at a catalogue of the University of New South Wales and it seemed to me that there was the ideal university. It was based on the fact that in that university a man could acquire an education in any subject that related to the industries of New South Wales. He could become a lawyer or a doctor, or a professional engineer, or a tradesman of any class, a farmer, a sheep-raiser, merchant, or anything that the industries of New South Wales could possibly ask a man to become.

It seems that this is the true democratic idea, that there is a place where a man can go in with any requirement whatever and get instruction for which he is best fitted or desirous. The speaker has recently been a little mystified as to what is the difference between the professional steam engineer and the engine driver. There used to be a very marked distinction.

The starter and stopper was not as much of an engineer, but he has now developed into the power-plant engineer, the kind of an engineer that requires a great deal of ability, of intelligence and of education, partly technical and partly practical. But there are comparatively few engineering graduates that hold the position of engineers of power-plants. They are developed from the engine-drivers and firemen. It would appear that the trade school and the correspondence school are going to be the schools that will bring the right kind of education to these men. A recent observation impressed that very strongly. The chief engineer of a plant, who had a very limited education was expected to know how to install engines into a plant, how to tell the employers what size and kind of engine to put in, whether he should use electric motors or not and all these things which usually come under the direction of a consulting engineer. As that man was supposed to know them he should have opportunity to get the kind of education he needs, through trade schools or correspondence schools, and there is going to be a great demand for engineers of that type, whether you call them engine-starters or engineers.

Professor Allen.—In answer to Mr. Kent, the speaker wishes to say that it was not his purpose to limit in any way the opportunity for the man who wants the trade school. The fact that the subject of correspondence schools has been taken up so pleasantly in this Society seems to dispose of that very well. The fact that there are in our membership men whose application came as members of the in-

structing force of correspondence schools indicates that the position is not taken that these various schools, correspondence or trades schools, should be discouraged. It is barely possible that the best good that can be done to those schools by the engineering colleges is that the engineering colleges shall be disinterested friends. The question to the speaker's mind is whether the engineering school should limit the exercise of its energy to more properly engineering work, and when it is said that a college is a place where anybody can learn anything, it should be taken for granted that the place is not included where the infant of three days old is taught to imbibe milk and water.

Professor J. P. Jackson.—It was a little surprise to hear Mr. Kent say that the position of chief engineer, mechanical or electrical, was one held by uneducated men. The speaker's impression and experience is that these positions are largely held by technical college graduates. Some personal contact with the work of leading correspondence schools has converted him from the opinion that such schools are of comparatively little use; or that those who are enrolled are drawn into something which they but half understand and which serves no other purpose than to rid them of a certain amount of money in fees. During the last few years the speaker has been a good deal in the bituminous and anthracite coal regions of Pennsylvania, and has not visited a single operation where he did not meet one or more men who had been or were taking courses in one of the correspondence schools. In every case, it can be said without

question, that the men were enthusiastic as to the value they were getting from the course. In many cases they had, as the author of the paper said, received promotions purely on account of the knowledge they had gained through this education. That experience has completely converted the speaker to the belief that correspondence education is excellent for certain classes; namely, for manual workmen who have not the financial ability to go to an educational institution. If in addition to the present work, these correspondence schools, through the aid of colleges or states, can form centers numerous enough to enable such men to spend a few weeks each year, where they can have any errors corrected which they may have formed in their own reading, it can be safely said that the field of correspondence education will have become one of the most important aids in the development of industrial work.

PROFESSOR E. ROBINSON.—The speaker belongs to an endowed school that started five years ago in northern New York, the Clarkson School of Technology. It started in with about five two-year trade or mechanic-arts courses and one four-year course in electrical engineering as a natural evolution from the others. The two-year courses have now entirely dropped out and there are three engineering courses: electrical, mechanical and civil, and nothing else. The reason for this change seems to have been that the two could not go together. Everyone that came into the mechanic-arts courses wanted eventually the engineering. If they came straight with that idea they passed into the engineering. This probably ex-

plains why colleges like Cornell and others have grown out of the mechanic-arts courses; that the two cannot go together if they would; they must be run separately.

THE DANGER OF EXCESSIVE SPECIALIZATION IN UNDERGRADUATE ENGINEERING COURSES.

BY JAMES C. NAGLE,

Professor of Civil Engineering, Agricultural and Mechanical College of Texas, College Station, Texas.

In several of the papers that have been read at meetings of this society some reference has been made to the tendency towards too early specialization in engineering courses and the possibility of unsatisfactory results therefrom, but the importance of the subject justifies further reference to it, if for nothing more than again to call the attention of the members to what appears to be a dangerous tendency in engineering education.

The century that has just closed has witnessed not only marvelous development in all industrial lines, but a complete revolution in educational systems as well. While progress in material things has doubtless been the most important factor leading up to changes in educational matters, it is likewise true that changes in the form and character of the higher education particularly have been potent forces in bringing about a general interest in, and persistent search for scientific truth. It is no longer necessary that one be trained along the old classical lines in order to be considered an educated man, and all intelligent peoples recognize the efficiency of a training that is more or less industrial in its character. Indeed, this tend-

ency has given rise to an exaggerated idea of what industrial training is, to an extent, that leads one to ask if there is not danger of carrying the matter too far. In engineering this seems to me to be the case, and, when one considers that three quarters of a century has not yet passed since the first graduate civil engineers came forth from an American institution, and that in that time the work of such engineers has grown to such an extent that it would be hazardous to even attempt to name the various titles under which they now do professional work, it requires no stretch of the imagination to see that the very object aimed at in specializing in this work may be defeated by carrying the matter too far or by beginning it too early.

The variety of work that confronts the engineer of to-day is so great, and the pressure upon his time and energies has been so terrific, that more and more restricted specialization has been the inevitable result. The technical schools have felt this pressure, and in their effort to meet the demand for engineers fully trained in some particular line of work, have tended more and more towards a similar specialization, and have increased the number of courses that may be selected by the engineering student. The last quarter of a century has witnessed the growth of an alarming number of such courses of study each leading to a titled degree that would seem to indicate that the graduate, fresh from college, has mastered at least one particular branch of engineering.

Each of these engineering degrees is based upon the successful completion of a course of study that is sup-

posed to supply the most essential things that the graduate will need in professional work, and in the effort to supply the essential things it would appear that sometimes it is forgotten that no amount of school training alone can justify a young man in assuming a title that indicates a large amount of practical experience, coupled with a thorough theoretical knowledge of the principles upon which his work is founded. It is certainly advisable that the graduate from an engineering course should be able to do at least one thing well, but it is neither necessary nor desirable that he should be an expert in this, and it is certainly not desirable that apparent proficiency in one line should be secured at the expense of a general training in the principles of engineering, or, for that matter, in general training in a broader sense.

The work that an engineering graduate first has to do after leaving college will necessarily depend largely upon circumstances. He is fortunate, perhaps, as far as his immediate advancement is concerned, if he can find an opening in the particular line of work for which he endeavored to prepare himself at college, but if he should fail in this he must take the most promising thing that presents itself. In some localities there are better opportunities in one line than in others, and if the young engineer is compelled to enter upon a line of work different from that in which his special training was received, he must trust largely to native ability to help him over the rough places until he has had time to pick up such information as he most needs at the time. It is rarely the case that he will be able to find the time, or will have the in-

clination, to dig down to foundation principles if he has not done some work of this particular kind at college. He will be more than likely to accept such methods as may be found ready made—the result of some other man's experience—which may be faulty in their nature. Even should his work happen to be along the particular line covered by his college course he will find that he needs a breadth of information far beyond that covered by his course of study, which even the best students only partially assimilate during college days. A thing that may have appeared quite clear in the lecture room, where all the conditions were fully stated, and where the instructor could be relied upon to discover and correct mistakes before serious harm had been done, will seem quite different when viewed in the light of practical work, and if the problem happen to be one that is entirely different in its surroundings from anything taken in the class room, or college practice course, the difficulties will be greatly increased.

Obviously, the man who has had the broadest and most general educational foundation will make the most satisfactory progress in a varied practice, such as any qualified engineer has to encounter. The successful engineer in any line is the man who combines the thorough understanding of theoretical principles with an intimate knowledge of the details of his work, and who has sufficient judgment to discriminate clearly between the various factors with which he has to deal, whether they be purely natural factors or have a human element in them. Such a man does not necessarily have to acquire these things at col-

lege, and some of them undoubtedly can only be acquired in active practice, but a preliminary college course does make for economy of time and energies in any case.

The day of the so-called "practical man" is passed when it comes to the higher orders of industrial work, for whether the information be acquired at college or elsewhere a thorough knowledge of theoretical principles is just as necessary as is a knowledge of the details of practice. There is no question but that clear and logical methods of reasoning can be more easily acquired at college than elsewhere, and if such habits have been formed it does not so much matter in what line of work the student may have taken his course. When he encounters a difficult problem in practice his habits of thought will lead him to seek for, and, if possible, find the fundamental principles underlying the work, and afterwards to adapt the material at hand to the end in view. The success of some such "theoretical" men has led to the contention that a purely theoretical training is best for college work, leaving the young man to acquire the details while engaged in active practice. However, it is hard for a man so trained to understand that to acquire this knowledge of practical details he must begin right where the young fellow who has never been to college has to begin, and that if he omit this his lack of knowledge of details may be the cause of serious mistakes later on.

Many general principles may be impressed upon a student by illustrating their applications to engineering practice at the time the principles are presented,

but the application should be used merely to illustrate the principle, from which it should be clearly distinguished, so that the impression that the application is the more important of the two would not be left upon the student's mind, as it sometimes happens is the case. Educational development of the mind should be, and is, the real object of every engineering course, but it is necessary to impress upon the student that it is mental development that is aimed at, rather than to fit him with the equipment for earning a livelihood after graduation. That this educational development can be secured by means of instruction along lines that will leave the student with some capital in the way of useful information, ready for immediate application, there is no doubt, and in the recognition of this fact lies the essence of the difference between the old form of education and the new. Still, this tendency may be pushed too far, so that the resulting graduate is not really an educated man, and it appears to me that if this has not already been done in some instances there is danger that it will result from the ever-increasing leaning toward specialization in the early stages of engineering education and industrial training generally.

The age at which a student is admitted to even the best of our engineering colleges is so low, and the judgment of such a student is so immature, that it is impossible for him, on entrance, to make an intelligent selection from among the variety of courses, or groups of studies, open to him. It is barely possible for him to even say that he wishes to take an engineering course, to say nothing of selecting one from a

dozen or more groups of studies leading to engineering degrees. It may be that those who are charged with his guardianship decide this for him, but they are not themselves always competent to judge of his fitness for some particular line of work, nor of the character of that work. The result is that he very often selects his course at haphazard. It is surprising what trivial things sometimes cause particular selections, especially if a selection must be made at an early stage of the student's training.

Once launched upon a particular line of studies it is difficult for a student to change to another should he find, later on, that the line he is taking does not suit his taste or qualifications, so he goes on to graduation in a distasteful work rather than lose a year or two in order to change to a course which he thinks would have suited him better. Even should he be able to make the change without serious loss of time it might be that he would find himself no better fitted to the new course than to the old one, for, before beginning the work he can at best have but a hazy idea of what lies before him. I believe that this is a fruitful cause of so many engineering graduates failing to follow professional work, either because they never enter upon it or because they find, on trying it, that the work does not suit them or they the work. A relatively large percentage of graduates from even the best engineering schools drift into business, or into some other profession. Of course this is true, in a measure, of all who are trained for professional life, but while we may point to many engineering graduates who have, subsequent to their engineering gradu-

ation, studied law or medicine, etc., it is rare that one can find a graduate from a school of law or medicine now practicing engineering, who was not an engineer before having begun the practice of such other profession. A good engineer needs to have fully as much special training as does a man in any other line of professional work, and in addition he must possess a fund of general information that does not appear to be so necessary in most of the other professions.

If the college training has been general enough it does not make much difference which branch of engineering the student has studied there; when he goes out into practice he will be able to take up other lines of work as they present themselves. Take the alumni catalogue of almost any of the engineering schools of long standing and note the number of men who have taken a civil engineering course and it will be seen that a relatively large percentage are following lines of work that require an intimate knowledge of mechanical or mining engineering, etc., while a similar percentage of the mechanical engineering graduates are pursuing lines of work totally different from that which they took at college.

The various types of engineering work overlap to such an extent that it is difficult to say where one ends and another begins. The civil engineer who has to design a draw bridge, a water supply system, a sanitary system, etc., has need of considerable knowledge of the principles of mechanical engineering in order that he may decide upon the type of mechanism or machinery to be used, but it it rarely the case that he can fall back upon his college course for more than a

very general reference to such matters, but even then he is better prepared for this class of work than is an electrical or mechanical engineer to take up some form of civil engineering, such as the location and construction of railroads, reservoirs, waterworks, sewerage systems, bridges, etc., because the latter has generally received little or no training in the fundamental principles underlying such work or rather, in lines that would suggest what principles to apply in such cases.

But with so much to be learned in the short time a young man devotes to his college course it may well be asked how can he, with the multiplicity of important things in even one line of work, cover the ground necessary to an understanding of even the general principles underlying so many branches of work. The suggested solution is to require more time of him than he now devotes to the work, or to leave off much of the elaboration now given in each course, or better still, to combine both methods. If a student enters college at the age of sixteen or seventeen years he is young enough to be able to spend at least five years in fitting himself for the duties of practical life, and if he should not be able to begin professional practice until he is twenty-three or twenty-four years old it is probable that his progress would be so much more rapid than had he gone out earlier, and that within a very few years he would have passed the point at which he would probably have been had he gone out earlier and with less preparation, provided that the last year or two at college have been devoted to study along lines that bear directly upon the work he has

afterwards had to follow, and that he begins this specialization with a broad general foundation.

It has appeared to the author that the older men in the engineering courses generally get a better hold on the subject matter taught them, and that afterwards they make more rapid progress, than the younger ones do, and it seems to me that this is because the more immature minds of the younger students are not able to fully digest the subject matter of the higher class work given them towards the latter part of their course. There is occasionally a man who remains so long a student that he loses confidence in himself by reason of too long study and dependence upon instructors. The author had one such man in his own classes whom he advised to take a minor position that was offered, in preference to remaining for a longer period of advanced work at college. This man was then not far from thirty years of age—much older than the average age at graduation—but on going into practice he proved to be a very good man and in the course of little more than a year he was ahead of his classmates who had gone out two years before him.

It has been argued before this Society on a former occasion that three years should suffice for the necessary course in engineering, but this necessarily presupposes a preparation that most institutions find it impracticable to insist upon, even as the engineering college work is now conducted. The author should prefer to see the time made five years, and believes that the results would be better in the long run. Much of that class of instruction that is general in its

nature, but necessary as the basis upon which to begin engineering work, can be more efficiently done in an institution that will adapt it to the future needs of the student, than in the secondary schools where it frequently appears to be the purpose of those in charge to stuff the young mind with a smattering of a multitude of subjects—many of which degenerate into mere memory exercises—instead of insisting upon a thorough understanding of, and proficiency in, a few of the most important ones.

Of course, any training that will cultivate the reasoning powers is of value, though it may never be directly applied in professional work, but it would seem clear that in an institution which proposes to teach the professional part, some, at least, of the foundation work can be better done than in a preparatory school, unless the work of that school is directed towards preparing its students for a particular line of advanced study. It is believed that the engineering college should give some instruction in English, French, German, physics, chemistry, etc., and of course, in mathematics. Nor should the more elementary parts of mathematics, such as geometry, trigonometry, algebra, be passed without some work in the college, no matter what the requirements for entrance may be. Among the author's own students deficiencies in algebra are more noticeable than those in geometry, but this may not hold with students in the higher grade engineering schools. This deficiency is particularly noticeable in equations involving numerical solutions, where the student seems frequently to doubt the correctness of his own work. However,

the conditions that surround the land grant colleges are radically different from those surrounding the older, and better equipped engineering schools, for a mistaken notion of the function of these land grant colleges makes it difficult to insist upon the same degree of preparation, for the most part, that is required by engineering institutions of the first rank.

A large percentage of graduates from even the best of the engineering schools are noticeably deficient in the proper understanding and use of the English language, not in the higher branches of literature and philology, but in the everyday use of the language as it should be spoken and written. While it may not be desirable to occupy the time available for college work in giving instruction in the elementary branches of language, it would be better to do this than to let the student go out unable to express himself easily and intelligibly in a written report, even though this instruction should be given at the expense of a little time taken from some other subject. The time given to this class of instruction need not be great, but in that time a critical study of the structure of the sentence should be made, and the student should be required to write a great deal, for only by much practice in writing, and by a good course in general reading, can proficiency be attained in this line.

As regards the technical work done at college it seems that all engineering students should have instruction in the theory and use of surveying instruments, in shop work, in the principles of electrical engineering (including work with measuring instruments, generators, etc.), hydraulics, mechanics of ma-

terials, the fundamental principles of sanitation and perhaps a few other subjects. Of course, each branch of engineering, or group of studies, will require special stress to be laid upon some particular set of these and related subjects, but that accentuation should begin later than is now the case. The common ground in the mechanics of materials is, perhaps, greater in extent than in any of the other subjects mentioned, and it can be covered with one set of instructors with more economy to the school than if a number of instructors in different departments are required to duplicate each other's work more or less fully. The more elementary work in the testing laboratory, and in experimental engineering generally, can be profitably taken as a common course, for the students in mechanical, electrical, mining, sanitary engineering, etc., need experimental work in the strength and behavior of building and structural materials, while the civil engineering students need practice in testing mechanisms and machinery, boilers, pumps, etc. In the principles of sanitation all engineering students should have instruction, for life and health are the most important things in this world, and if some little laboratory work could be given to fix the principles of sanitary science so much the better. All engineers need to know something of hydraulics, and some experimental work in this line will benefit them all. Some of the exercises in these subjects will illustrate some special feature of one group of subjects more than the others, but it is well for the students in all the courses to see and appreciate the meaning of such exercises, for if they do nothing more than to give

those who intend taking a different group an insight into the special features of this particular group the time will have been well spent, and a closer relationship will be established in later life between men who are working along different, yet related, lines.

It is believed that this common course should extend through the junior year, so that the differentiation would begin at entrance upon the work of the senior year. By that time the student would have gained a sufficient knowledge of the principles of engineering to be able to make an intelligent selection for himself, and in the year following would be able to do particularly good work in his line. Indeed, for most of the engineering schools, not of the very highest rank, it seems that it would be better to make the courses identical for four years, and then do the special work afterwards in graduate courses.

But what degree should be conferred upon a student who has taken a course such as the above, especially if it should extend through the senior year before specialization was begun? On the whole, it might be better to confer no degree whatever at the end of the four years, but instead to give the student a simple certificate stating what he had accomplished. He would then be much more likely to come back for a more advanced course, because, being once armed with a diploma he is likely to think—or his parents and friends will naturally assume for him—that he is fully equipped and ready to meet and surmount the difficulties that will present themselves in practice. By far too small a proportion of our engineering graduates return for advanced work after

receiving their first degrees. This would be largely corrected by refusing to give a titled degree until it is really deserved. However, if it were thought desirable to confer some kind of degree at the end of the usual four years' work, this degree should be simply "Bachelor of Science," and in the diploma the statement could be made that the work done was in the engineering course. The titled degree, indicating special proficiency in some particular line, should come later, say after at least one year's resident graduate study and a certain minimum of practical work in the profession, the character of this professional work to be in line with the studies taken during the period of resident graduate study, thus insuring that the student has received some light upon the subject-matter of his course outside of what he has taken in the class-room. To this practical work might be added a certain amount of study in absentia, upon which the student might be examined after he has satisfied the requirement regarding professional practice. The degree should be given at any time the student can satisfy the necessary requirements. This would tend towards the abolition of that annual bore, called commencement, that not only involves the college and the student in unnecessary expenses, but which sends the graduate out with an exaggerated estimate of his own equipment and importance.

What has been stated has been somewhat disconnected and trite, but it is believed that the importance of the subject is a sufficient warrant for calling the attention of the members of this society more specifically to it than has been done before. So great is the

pressure upon the time and energies of the practicing engineer that he has little time to turn from the study of pressing details to a consideration of the fundamental principles of his profession, and, therefore, it would seem obvious that if these principles can be firmly fixed at college better results will follow than if the few principles that are given are hidden under a mass of details which the student's experience does not enable him to distinguish from the principles themselves.

This society has a standing committee that is charged with the consideration of the important matter of entrance requirements, and this committee has done valuable work. However, it is not the character of the preparation that a student has at entrance to college that affects his life work so much as what he knows and the character of the man he has developed into at the time that he goes out from the college halls; although, under the present system, it has an important bearing upon his standing at the time of graduation. It seems to the author that it would be most desirable to have a committee to determine what should be the conditions under which a student should be graduated, for it does not really matter much where a man's preparation begins, provided that when his preparatory work is completed he is fully equipped for the work that lies before him.

Discussion.

Professor J. P. Jackson.—There is one class of institutions which are very apt to over-specialize, and they are those which teach one or two technical

courses without having a sufficient faculty or equipment to train what some have been calling an all-around industrial engineer. A college, for instance, which gives a course in electrical engineering only, along with courses in classics, literature, and other general subjects cannot but over-specialize in pure electricity on account of the lack of allied engineering training. Colleges which give merely civil and electrical engineering are more or less subject to the same evil and to guard against the hasty creation of such courses is in many respects of far more importance than the question of preventing over-specialization in the best of the land-grant colleges, where there is a full engineering faculty and every man has an influence in fully rounding out the student's mind.

Professor Lanza.—There is one point which Professor Nagle mentioned that the speaker supposed was not true; perhaps our statistical committee can tell us whether it is true or not. Some time ago some statistics were compiled in regard to the occupation of graduates of the Massachusetts Institute of Technology in mechanical engineering, and it appeared that the number of men who were not following engineering work was considerably less than ten per cent. Professor Nagle gave the impression that there was a large proportion of graduates in engineering who did not follow their professional work. That is certainly not so in the institution named.

Professor Nagle.—Relatively a large portion, ten per cent. is larger than it ought to be.

Mr. Kent.—Both of the preceding speakers have seemed to criticize some points in Professor Nagle's

paper, but the speaker wishes to express his hearty commendation of it from beginning to end. Professor Nagle is entirely right in his criticism of the danger of over-specialization in engineering schools. He says that a graduate should be able to do one thing well. He may be able to do two or three things well, such as drawing, computation, and observation with instruments, but it is doubtful if the ordinary engineering graduate does any one thing well which qualifies him as an engineer of construction. He may be able to do certain things which he is set to do but he is not yet an engineer capable of directing the work of others, and nearly all engineering graduates need a post-graduate engineering course of one or two years in the shop, at low wages, before they are competent to really say much about their ability as engineers. In regard to when the differentiation should take place, Professor Nagle says at the beginning of the senior year. In some colleges it takes place earlier, in others, not until after the senior year is over or not until after graduation. It depends on the entrance requirements and on the character of the colleges. Some colleges are turning out graduates so young and so insufficiently equipped that they are practically only at the beginning of an engineering course, and do not yet know whether they are going to be civil or mechanical or mining engineers. There are other places where the differentiation can take place at the beginning of the junior year; say a college which has very high entrance requirements and finishes mathematics before the beginning of the junior year. The student then, at say 20 years of age, is probably com-

petent to judge whether he is going to be a civil, mechanical, or mining engineer. He is not yet believed to be ready to say whether he will be an electrical engineer. The speaker is entirely in favor of the practice of Stevens Institute which gives a very severe electrical engineering course but does not call its graduates electrical engineers. It gives its mechanical engineering graduates very little civil and mining engineering, but it turns them all out as mechanical engineers with some knowledge of all the other branches and a strong knowledge of electricity. It seems to be better to train mechanical engineers that way than to try to have a course of electrical engineering. In regard to these other differentiations of hydraulic and sanitary engineers, they are branches of civil engineering which should be taken up after graduation; ceramic engineering or sugar engineering and a lot of other specialties, like railway engineering and marine architecture, are all things to be taken up after the man had graduated from his four years' engineering course.

PROFESSOR ALLEN.—At the institution with which the speaker is connected the differentiation is begun in part in the middle of the first year. Bearing upon the point as to whether the specialization should occur after the four years' course, or after graduation, it is fair to state that the graduate in mechanical engineering will find much difficulty there in taking the subjects necessary for his civil engineering degree in two years. And vice versa. So far as all the subjects taken in the specialization are subjects which have the proper training value and are subjects that are strong

in that way, it is difficult to see where any serious danger comes. If subjects are taken which are lacking in training value, specialization becomes seriously unwise. As a matter of fact, in our best engineering colleges there is a range of subjects possible, all of which have most excellent training value. They train the man so well that without serious difficulty he can, after graduation, himself prepare to do excellent work in other directions. Within a week the speaker has talked with a civil engineering graduate from his institution and found him engaged specially in mechanical engineering, he having made the change with some assistance, but mainly as the result of a good deal of solid and substantial individual work. The point to be emphasized is that, so far as the subjects have good training value, specialization is not unfortunate.

PROFESSOR MAGRUDER.—Answering Professor Lanza's question, the speaker believes that it can be shown that a larger percentage of the engineering graduates follow engineering as their life work than those in any other profession. The dean of one of the large medical schools once said that it was a good thing for mankind that only 10 per cent., of their graduates ever practiced medicine. More nearly 90 per cent. of the engineering graduates practice engineering. The ratio is 93 per cent. for the Ohio State University. Referring to a statement in Professor Nagle's paper, no apology need be made for the so-called land-grant colleges. The speaker is not a graduate of one, and hence can speak more freely on the subject. When one thinks of the Massachusetts Institute of Technology and Cornell in the East, of Wisconsin and

Minnesota in the North Central States, and of California in the West, as being land-grant colleges, it appears that some of the largest and strongest of our educational institutions are land-grant colleges.

PROFESSOR NORRIS.—In Sibley College but one first degree is given and this is for mechanical, electrical, marine and railway engineers, the idea being to have these as much alike as possible as undergraduates and to have the specialization take place in graduate schools, some of which have already been established in the college. In the past few years, however, there has been an increasing desire on the part of the students to have their undergraduate courses molded along the lines of their proposed specialties. In the department of electrical engineering, for example, there has been, as early as the junior year, a demand for different courses in the study of electrical machinery for those who intend to follow this line as a life work and for those do not. The resulting separation of the junior class, as effected this year, into electrical and non-electrical engineers has produced satisfactory results to both classes, for each attacks the same subject from a different standpoint, and one adapted to its peculiar needs.

PROFESSOR LANDRETH.—Engineering educators have two opposing tendencies to face in answering the questions which the paper emphatically suggests, namely: First, what shall be the proper length of the engineering college course? Second, what shall be done with the time in that course? Considering the first question, the engineering schools are between two fires. First, a demand on the part of certain educators that

the course should be lengthened; that is to say, that it should be probably a five years' course; and, on the other hand, a demand on the part of certain sensationalists and some of the people who insist on utilitarian instruction mainly, that the work should be shortened to a three years' course. Now, it seems that without any attempt to harmonize these two extremes for harmony's sake, experience has settled on about the right length of course, namely, a four years' course, and that improvements should be made not in the direction of increasing the length of course, but by increasing the efficiency of the work of the course by beginning at a higher point, that is by further advancement in entrance requirements, and also in such an arrangement of the course as will permit the student to utilize his time to the best of his ability without overloading. A reduction to a three-year term is out of the question; and an extension to the five-year term experience shows to be at present unwise for the rank and file of engineers. There is no doubt that for certain cases, for certain men who are going into certain vocations, a five-year course is desirable, but for the rank and file of engineers four years seems the proper length of term to provide. As to the appropriation of time in that course the belief has grown that four years is none too long for the fundamental work required of all engineers and is too short for much if any specialization. At Union College the first three years of the three engineering courses are general, there is no separation whatever, and one of the strong reasons which has led to that arrangement has been not only the important one of occupying that time by general founda-

tion work but that it has permitted the student to defer the selection of his specialty until the latest date possible. The guiding criteria which seem to be the proper ones in selecting the work for the course, should be two: first, what subjects, disciplinary, cultural and technical, will be of the greatest value for the development of the engineer in general and, secondly, what list of studies following these, and as nearly as may be in keeping with them, will be of the greatest utility to the largest number of special divisions of engineering.

PROFESSOR J. B. JOHNSON.—At Washington University, St. Louis, the straight five years' course was tried for five years, no graduation being given at the end of four years and it was abandoned as unwise pedagogically. The average engineer ought not to spend more than four years in college. He acquires those habits of the recluse, of the student, and of the man of books which more or less unfit him for the rough-and-ready practice of engineering. So the speaker is convinced that it is unwise to establish regular five-year courses. The prevailing practice in this country is just intermediate between the English and the German practice. German engineering schools would correspond to a five-year course in this country; the English schools, in all the British dominions, with the exception of Canada, are three-year courses. The speaker believes that the practice here is just right and that both the German and the English are coming to the same conclusion. If a man wants a five-year course he can take it in almost any of our engineering schools; if he is going to teach or specialize in some particular direction or change his course from

mechanical to electrical, or to civil engineering, for instance, then he can go back and get the extra amount of work. Furthermore, the degree of specialization indicated by the name is not nearly as much as most people suppose. That is, what is the difference between a course in sanitary engineering and a course in railway engineering? It is extremely little. Then you say, why do you give the two names; why don't we simply call it civil engineering? It is part of our yielding to public demand. A parent will say, "I want my boy to be a sanitary engineer, and as I see you have no such course I will send him to the Massachusetts Institute." Similarly with a course in railroad engineering. The people demand these special courses, and the schools yield as to the names, but they make comparatively little difference in the work given in related courses, so that no great harm results.

Professor Goss.—Just a word with reference to the completeness with which the graduates of engineering follow engineering work. The speaker agrees with Professor Lanza in what he has said, as he had occasion to look up the facts himself and knows that a very large percentage of engineering students follow engineering work but he does not think that is very important. As he looks upon it the purpose of an engineering course is to train men for life and he recognizes the fact that there are many business positions which require men who have had such training as is given by engineering courses. It is, therefore, altogether fit and proper that graduates in courses of engineering should in many cases drift off into business

and when this happens it is not to be regarded as a failure of the engineering course.

PROFESSOR WALDO.—It seems that the paper raises the question which was propounded something over eighteen hundred years ago, "What man is there of you whom if his son ask bread will he give him a stone?" and it is believed that this country is arriving at a point in civilization and development when its young men who come to its various institutions of learning have about as clear notions of what they want as the teachers have of what is good for them, and if a college is foolish enough to stand against their demands it will find that the young men will be sensible enough to go somewhere where they can get what they ask for, and the speaker thinks that it will be found frequently that the young men are more nearly in the right than the professors. They have come from bread-winning families and these families know what they want and what their children want and if the college cannot or will not provide the necessary training for them to fill certain positions they will go where they can get that training. Curriculum makers have their faces to the past when they affirm that a man must go through a certain routine before he chooses his profession or before he is allowed to choose his profession. The young men that come to our engineering schools are usually fitted by birth and nature for the career of the engineer. Early specialization gives them early knowledge and proof of their own natural endowments.

In general an early choice of profession and specialization in it made with the advice and consent of

parents and friends will not go far astray. In the few cases where it does, an early specialization discovers the fact before it is too late to turn about and do something else successfully.

Professor Talbot.—It seems that a distinction ought to be made in this discussion of over-specialization, between specialization and over-specialization. All engineering educators, it is believed, agree that the most important part of engineering education lies in general training and foundation principles; but training in general principles is not sufficient, and the student who gets only general principles is not likely to appreciate many problems and many discussions involving these principles.

The training in details given by the specialized courses, the experience in the application of principles to minor matters and the cultivation of the proper attitude of mind toward such applications, is of considerable importance. The man who takes up questions of detail for the first time after graduation is very likely to be puzzled and troubled with very small matters. In this respect the student of specialized courses has an advantage. No matter what the line of study that may be, a limited amount of work in detailing and in applications will be advantageous. The training to observe along a special direction is beneficial. It may be, as Professor Allen has stated, that he will afterwards go into another line of work, but this training along special lines gives a development which will be of service to him whatever may be his after-work.

Professor Frank B. Williams.—There is one point

that has not been brought out and that is, the effect on the student himself. If a student is allowed to choose for himself very early, he gets the idea that there are only certain things he needs to know, and other things seem less important or indeed useless. Consequently, he neglects many important subjects that he really needs in his profession. The Federation of Graduate Clubs has taken a great interest in specialization in general and, in its opinion, the idea has been carried too far. The pendulum has taken too great a swing, as it does in almost all reforms, and the tendency now is to go back a little, and not allow students to specialize quite so early. More nearly equal weight will then be given to *all* subjects, a better foundation for future work will be laid, and more rounded and better cultured men produced.

Professor Harris.—If a man were required, before he specializes, to take twelve months of actual practice, making that a condition of specialization, it would throw a great deal of light on the matter, to see how many would return to take a special course. It is doubtful whether some of the old institutions would dare to make such a test. The matter settles down to this: is it the best use of the student's time? No doubt it is profitable to him to specialize but would he not get more benefit from that 12 months if he were in actual practice? It is not believed to be in human nature for a young man, without any practical experience, to get the benefit which he expected to get from specialization, until he goes into practice. The speaker has actually persuaded students out who were inclined to stay in another year, seeing that they

positively needed the burning-in effect of responsibility, needed the intense interest which they would take when they feel responsibility. The absence of it where they are merely doing class work makes an immense difference.

PROFESSOR ALLEN.—In answer to the question of a year's absence, it may be said with relation to the institution which the speaker knows most about—and it may be true of a number of others, that it is not at all uncommon to have men come to take the specialized course in civil engineering or the specialized course in sanitary engineering after they have been a number of years in practice. These cases are by no means rare.

PROFESSOR D. C. JACKSON.—The speaker hopes that he will not be considered flippant if he says that the discussion of this subject almost always reminds him of a song his grandmother used to sing, which ran something like this:

> "Could man be sure that life would endure
> As of old, for a thousand long years,
> What things he could know, what deeds he could do,
> And all without hurry or care."

It is impossible to learn everything. The specialization that the Federation of the Graduate Clubs objects to, which has been spoken of here, is an entirely different matter from the specialization that is found in the engineering courses. For instance, this plan has been carried out in some of our colleges: a man begins to study history when he is a sophomore and he does not study much of anything else until he gets his doctor's degree six years later. Now, that man

knows nothing except a little history. He hasn't received enough of a side view even to get perspective in his main subject and his course is very objectionable.

Specialization as it is ordinarily considered in the courses of the better engineering colleges is a very different thing—it consists in a good sound training in certain branches of the physical sciences and their applications, and as long as the fundamental physical sciences and their applications are taught and that soundly, the colleges will not be doing any injury to the students but will be giving them a magnificent education.

The sound teaching, however, is a matter of great importance. It is very difficult to teach well, but that is no excuse for poor teaching.

On the other hand, in some of the colleges specialization is called, what? It is called "engineering practice," which is a phrase often used to cover a multitude of sins. In many of our colleges, the phrase engineering practice means sound professional training in the applications of the sciences, especially the principles of physical science. In some of the colleges, however, as stated, that name covers a multitude of sins and stands for "information courses," which are wrong pedagogically and from the human standpoint. They are wrong because they put the teacher in a false position in respect to his students, and because they waste the time of the students. Such specialization as this is faulty because it is superficial and it has no business to exist in an engineering school; but the specialization wherein the civil engineering course gives electives in railway engineering, sanitary engi-

neering, and electrical engineering, and the mechanical engineering course gives electives in machine designs, steam engine, hydraulics, and electrical engineering, or the electrical engineering course gives electives in various branches of applied electricity, is good, because one cannot learn everything. Those specialties which are allowed as electives and perhaps are even arranged under separate formal courses in our better schools, are just as sound in the applications of scientific principles as any of the other professional branches that are taught in the engineering schools and only good—not danger—is to be apprehended from them.

PROFESSOR HATT.—In the first three years in the majority of colleges the work is of real high-school grade; students come without any drill, without habits of close application to study, and it seems to the speaker that in the first two years at least the college cannot very well afford to give these information courses very much attention.

THE PROMOTION OF ENGINEERING EDUCATION AND GRADUATION REQUIREMENTS.

BY WILLIAM G. RAYMOND,

Professor of Geodesy, Road Engineering and Topographical Drawing at the Rensselaer Polytechnic Institute, Troy, N. Y.

A year ago I had the honor to present to the Society a very brief review of its work, and to make some suggestions as to what it might accomplish in the future. The title of the paper was "The Promotion of Engineering Education," and among the suggestions were these: that the Society discuss and, if possible and practicable, endorse a list of minimum requirements for the graduate engineer, and that it discuss the advisability of making the ordinary undergraduate course more general than is now usual, grounding the student in the fundamentals of the several branches of engineering work and providing for specialization in a post-graduate course. Probably because of these suggestions I have been asked to open a discussion of the first topic mentioned, namely: Graduation Requirements for the Engineer.

Feeling more or less at sea as to what requirements to suggest I sought help from members of this Society with the result that a considerable departure will be taken from the topic assigned, and a return made to the paper of last year: "The Promotion of Engineering Education." The reason for the change is this: With one or two notable exceptions all of the responses to the request for suggestions indicated a con-

siderable degree of satisfaction with things as they are, each instructor simply sending the requirements of his own school as embodying his idea of what should he done. Satisfaction evidences the advisability of a forward step.

It is true that a few responses indicated that the writers were not quite satisfied, but that some change in detail would make everything as it should be, and one or two responses indicated a belief that none of our schools are doing all that they should or can, and that the errors are rather fundamental than matters of detail.

As this idea has been growing in my own mind for some years, this paper will contain suggestions that are not simply the result of the thought of the moment, but rather of convictions—open surely to modification—but nevertheless fairly well settled convictions.

This Society stands for the betterment of engineering education. There are always two ways of attacking a betterment problem, one involving a study of large questions of general policy, looking to improvements of magnitude; the other, the study of details, not lacking in importance, but each item vastly less important than the matter of general policy.

Good teaching results from the individuality of the teacher. The normal school, any school, society discussion, all help to improve the conscientious teacher, but in the main the details of teaching any subject may be left with reasonable safety to the teacher. It certainly seems that such an organization as this has insufficient cause for existence, if, as would seem from the letters received, there is nothing but detail to

consider. If, in the main, our engineering courses are what they should be there is no reason for the considerable expenditure of money, time, and mental energy that this association involves; each school will take care of its own details for itself, while correspondence and magazine articles will bring out matters of greater importance and interest to us all.

Agreeing with the one or two members who have expressed dissatisfaction with general methods, I propose to suggest what seem to me two fundamental mistakes in our school work, and the remedies for them, with the hope that the suggestions may provoke discussion and develop ideas that will result in material improvement commensurate with the effort the Society is making.

Wasted time is the great fault of our present methods. It results from :

1. Too much vacation; the school year should be lengthened and the number of years lessened.

2. Class work instead of work with the individual.

3. The mixing of engineering subjects with preparatory and general culture subjects.

What seems to me to be another fault is specialization in what is usually an undergraduate course. The course for the baccalaureate degree should be general, involving the fundamentals of all branches of engineering; the professional or master's degree should follow advanced work in a particular department, either in school or practice as may seem advisable. I shall speak very briefly to each of these points.

1. Reduction of vacations. I am not familiar with

the all-year plan of work adopted by the University of Chicago, but believe it to be in the direction of what is here proposed. A lady, the daughter of an eminent lawyer, and widow of a well-known college teacher, said to me recently: "I suppose you will consider what I am about to say rank heresy, but do you know, I think college professors have too much vacation." I was glad to be able to say that I was preparing to take the same ground before this Society; although it is the student I am thinking of more than the instructors.

Depending on the extent to which Saturdays are used, on the number of holidays during the school year, and on the nominal length of that year, the actual working school year is from 30 to 33 weeks, with an occasional school requiring even less than 30 weeks and perhaps a few securing more than 33 weeks. Think of it, in any ordinary four years' course the play time is from 13 to 15 months or more; or, allowing for the ordinary business man's vacation, the student loses an entire year of work at a period when it is very important for him to utilize his whole time. It is true that some students use a portion of this time, but would it not be better for them all to be able to use it as a part of their permanent business life?

If eight hours a day be given to work, the course in general engineering that is mentioned hereafter can be accomplished by the average boy in two years' time, allowing a vacation of one month each year, all legal holidays and half holiday on Saturdays. The course represents about as much work as is done in engineering subjects in the good schools with which I am fa-

miliar, though the relative time devoted to the several subjects is unlike that prevailing in any school. In the course suggested, except in laboratory subjects, one hour stands for three, the usual two hours preparation and one hour class room work.

It is proposed, however, to make better use of the students' time than now, for it is believed that, where classes are large, not less than one-half the time spent in the class room is wasted. Doubtless you will say it is impracticable to make the changes suggested, but I have thought it out to a considerable degree of detail and believe I can see how it can be accomplished.

2. Individualization. It has long been recognized that continuous personal direction of the pupil by the teacher in such a way as to develop the best the pupil has is the ideal method of teaching. Class work has its value, and general directions and explanations, as well as points not covered by text-books, may be imparted by lectures and class room talks, but these should be the exception. Certain exercises require several persons for their performance, as surveys, engine tests and the like, but in the main the work should be with the individual rather than the class. This can be accomplished with a student old enough to begin engineering work. The method of doing it will vary with the ideas of the teacher or faculty directing the policy of the school.

The following is submitted as a very general scheme, not worked out in detail: There shall be provided one or two or more general lecture rooms, to be used by all instructors for class work, and for each teacher a large work room with a comfortable office adjoining.

The equipment of the rooms will depend on the subjects to be taught.

Each student shall pursue a single subject, or at the most two subjects, at one time and until completed. During this period of work in one subject he will occupy a desk, with book rack and drawing table (when necessary) attached, in the work room assigned the teacher under whom he works. Here the student will study, confering with his teacher when necessary, for, say, eight hours daily, until the subject in hand is mastered. He then goes to another teacher in another room. When the attendance is small and one teacher handles several subjects, the scheme is not essentially different, the student simply remains in one room longer, and the equipment of the room will vary.

The details have been somewhat more fully worked out in my own mind, but so long as the details are possible of arrangement, they are not worth discussing until the merits of the general plan have been determined. The idea is so to plan and conduct the teaching work as to secure close personal direction for each individual student, and as rapid advancement as his abilities permit.

3. Segregation of Engineering Studies. To secure the greatest economy of time the engineering course should be separated from the other subjects in the school. As it now is, some engineering subjects, as surveying, technical drawing, etc., begin in the so-called freshmen year, while descriptive astronomy, political economy, etc., are frequently left to the junior or senior year. In order to accommodate students coming from various schools, and the student

of advanced age and limited means but with a good head, who must prepare himself; in order to make the course attractive and economical as to time to college graduates, a class of students we should all like to see increase; and in order to carry out the plan already mentioned, it is desirable to separate the engineering studies from the other undergraduate courses; and to make the engineering course complete in itself.

Although it is not done now, we hope the time may come when we can require a baccalaureate degree for entrance to an engineering school. This time is only beginning to come for the professions of law and medicine, there being but few schools that have dared to make this requirement. Until the baccalaureate degree can be generally required for entrance to the engineering school, each school must determine for itself what shall be its entrance requirements, but to carry out the plan of this paper the preparation in mathematics must include the Calculus.

4. Generalization of the Engineering Course. The stock of engineering knowledge has become so great that few men master it all, and it is more than can be expected that a student will master the details of all branches of the profession while in school. At the same time, the various branches are so interrelated in all great engineering operations, that every civil engineer should know something of the principles of mechanical engineering, electrical engineering, mining engineering, etc., and *vice versa*. Therefore it would seem to be wise to teach in the school the fundamental

principles and general practice of all branches, making the accomplishment of a complete course of this character the requisite for a baccalaureate degree in engineering. Subsequent work of note in one or more branches either in practice or school may be rewarded with a professional or master's degree.

I feel incompetent to suggest advanced courses in the several branches of engineering work, but will submit the following outline of a general undergraduate course in engineering for discussion rather than as representing my own final judgment. This much of the paper covers the topic assigned me.

Physics—150 hours.

Chemistry—50 hours.

Engineering Materials, Geology, Mineralogy, Metallurgy of Iron and Steel—50 hours.

Mechanics—150 hours or less.

Theory and General Design of Prime Movers and Transmitting Engines—150 hours.

Theory and General Practice of Static Structures—100 hours.

Theory and General Practice of Road and Railroad Location and Construction—50 hours.

Theory and General Practice of Sanitary Engineering—50 hours.

Theory of Surveying—50 hours.

Drawing—300 hours.

Surveying Field Work—300 hours.

Physical and Mechanical Laboratory—300 hours.

Stating the hours spent in a subject is a somewhat unsatisfactory way of defining the extent of the course to be given, but it may be said that it is intended to

include so much of mechanics as is now given in any undergraduate course, and that the hours allotted to this and the other subjects will indicate the writer's first thought as to their relative importance.

It is felt that the suggestions of this paper are radical, and will perhaps be looked upon as impracticable and impossible of accomplishment, even granted that the plan outlined is desirable if practicable. It will doubtless be admitted that a new school can be organized on the basis here suggested, and I firmly believe that such a school would very soon be unable to accommodate the applicants for admission.

The plan is not new; it is essentially that adopted by the business college and the correspondence school. In these schools the student may enter at any time and graduate when he finishes his course. While there may be some practical difficulties in the way of adopting such a plan of work, there are also many things to be said in its favor that have not been said. It is hoped the discussion will bring out both the objections and the advantages.

MINIMUM REQUIREMENTS FOR GRADUATION FROM A CURRICULUM OF CIVIL ENGINEERING.

BY ROBERT FLETCHER,

Director of the Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H.

General Conditions and Pre-requisites.—The outline here suggested is intended to cover two academic years or about 70 to 72 weeks with an intermediate summer recess of about 20 weeks devoted to practice in some line of engineering. The last year is post-graduate, given exclusively to professional courses. On the following specifications it leads to the degree of *Civil Engineer*. For the degree of *Mechanical Engineer* obvious omissions and additions would be made: some topics being simply curtailed, others amplified and two or three entirely replaced. The scheme is not largely ideal; for the most part it is the outcome of the experience of many years and, in its leading particulars, has proved practicable and satisfactory under the conditions which the writer has had to meet.

The previous year, corresponding to Senior year of the usual college course should be devoted *almost* entirely to engineering studies, by election *of the course as a whole* and lead to the college degree of B.S.

Studies admittedly preparatory or auxiliary to be taken during the first three years of the college course, and in the secondary schools; these are: the usual mathematical branches including elementary practi-

cal courses in algebra (not going very far into "higher algebra"), geometry, trigonometry, analytical geometry and calculus, mastery of the principles of descriptive geometry and a first course in mechanical drawing, the essential elements of physics (including analytic mechanics in brief) and of chemistry, with only the *necessary* laboratory work in each, elements of descriptive astronomy, physiography and meteorology.

Studies which give mental breadth and culture may be varied according to aptitude and taste of the student. Evidently they should include, beyond the common school branches, a good acquaintance with English literature, and ancient and modern history (Latin during two or three years is at least desirable as a basal language and means of discipline), one modern language during two years, rhetoric to the stage of ability to write a creditable essay and speak with some facility to an audience, a brief course in political science and sociology, and elements of geology.

Preferably admission to the engineering courses should be only after special examinations held by or under the immediate direction of the responsible head of the technical school; the object thus sought is to test each student, irrespective of his previous record, in order to determine his general grasp of the essential parts of his entire preparatory course and his ability to use his knowledge readily in the technical applications.

General Requirements of the Course.—The practical instruction should be given to parties of preferably six and not more than eight under one instructor, who should give personal attention and example to

each students, and systematic criticism and correction to each note-book and computation book required to be kept neatly by each student according to prescribed standards; consequently the persistent aim must be to confirm each individual in the habit and methods of *checking* all his results. The preferred method of class-room instruction should be by recitation from well-chosen text-books, lectures being sparingly resorted to, and only when unavoidable, as in advanced work or for special reasons.

General Qualifications of the Graduate.—He *must* have a good understanding of and be adept in the routine practice of surveying, so as to hold his place under an exacting chief of party; he must be, at the start, an acceptable junior draughtsman and an accurate computer, able to make a good original, a good tracing and a blue-print; he must have a sufficient practical knowledge of the ordinary materials of construction gained by adequate manipulations in the laboratory and by such observation and experience as every available opportunity will bring to him; and he must have developed the habit and instinct of making neat and accurate and sufficiently complete records in a well-kept note-book, of the results of his observations and of his own work; also the habit and method of keeping himself well-informed as to engineering progress through current technical literature.

THE MINIMUM CURRICULUM. *Fundamental Subjects.*

Theory and Practice of Surveying.—A course which should occupy the entire time of about 20 weeks or 210

to 220 half days—as nearly consecutive as possible—in the class-room, field and draughting room. The half-day is reckoned at an average of four and one half hours; in emergencies it may be extended to five and one half hours.

1. *Instruments.*—Engineer's transit, dumpy-level, wye-level, prismatic compass and sextant; perfecting of all adjustments not required to be made by the maker; determining magnifying power of telescopes, sensitiveness of spirit levels and compass needles, etc.

2. *Preliminary practice* until a required degree of precision is attained, and in which each student shall acquire satisfactory facility and do himself, or as one of a party, a piece of test work of each of the following kinds: differential levelling; angle measurement in a small scheme of triangulation which is the basis of a systematic plan of survey for the season; a simple land survey involving ordinary measurement of lines and angles; measurement of a base line 1,500 ft. or more in length by steel tape and method adequate to secure precision measured by a probable error not greater than 1 in 75,000; solar observations with engineer's transit for azimuth, as early as convenient so that the method may be available as a check in other surveys; also star observations for latitude and azimuth.

3. *General Practice.*—One topographical survey for a small contour map, including part of a village or town; one stadia survey of two to four or more miles making a closed circuit for checks, following a road, streams, the entourage of a hill or a watershed divide; the routine of an ordinary railroad survey, preliminary and location, with some special practice in locating

easement curves; some practice with the aneroid barometer and the use of this with prismatic compass and hand-level in reconnaissance, if convenient. These surveys possibly may be coordinated so as to be plotted for the most part on one plan or map of the season's work, the office work for which will include the most approved methods of computing and use of planimeter and slide-rule, or more precise calculating machine when necessary.

4. *Special methods* and instruments, as use of the plane-table, photography in surveying, geodetical surveying, and special practice relating to city and underground surveys, etc., can only be briefly considered in the class-room, for the most part. There is scant time for them in a minimum course and they may well be put beyond the domain of the school, as the details are readily mastered by a proficient in what has preceded.

For the mechanical engineer this course would be cut down to less than one half in time and substitution made of machine drawing and laboratory practice. A considerable part of sub-heads 2 and 3 and all of four would be omitted.

Mechanics.—Principles of statics and dynamics, data and laws of friction, elements of mechanism, and important applications in the stability of structures, machine design, operation of hoisting machinery, action of the locomotive engine, etc. Sixty five half days. For the M. E. division this would be a little extended in the direction of machine design.

Materials of Construction.—Physical and chemical properties and mode of production of all used by the

engineer; comprehensive study of the iron and steel industry and metallurgy of copper and aluminum.

Mechanics of materials analytically; the most essential data from tests; tests by the student and experimental verifications with testing machines, including a sufficient laboratory course on cement mortars and concrete.

Masonry Construction and other Structural Work.—The modern use of concrete and metal, stone and brick masonry, foundations, dams, retaining walls, arches, the structural features of buildings generally and of slow-burning construction. At least two working drawings. About 140 half days for the two courses.

The courses thus far would require all of the first year which is assumed to cover 37½ weeks of *working time.* Parts of the last two subjects should be put into the second year for advanced study, and the elementary part of the two subjects next to be named taken in the first year.—The summer recess would be extended to allow time for practice on works, and the second year in the school made shorter by four or five weeks. The writer has accomplished this by opening the school session August 1st for the first-year men, thus securing an unbroken and favorable season for the long course in surveying, and having the last year men report six weeks later,—the session for all closing April 30th.

Framed Structures.—Graphical statics and other analysis applied to trusses for roofs and bridges; principles of carpentry and trestle building; brief study of the important details of the leading truss forms without going far into the field of "expert" practice.

From six to eight typical examples in graphic statics, and two or three designs, working drawings and tracings. 75 to 80 half days. (For the latter part of this course the M.E. students would substitute machine drawing and shop-work.)

Legal Relations of the Engineer.—Legal responsibilities and duties of the surveyor; specifications; law of contracts; duties of the inspector.

Hydraulics.—Mechanical principles and empirical data; motors and development of power; essential measurements and tests in an adequate laboratory; water supply engineering—purification and works for the same, systems of storage and distribution; not too far into the field of the expert, or into details of special construction. 45 half days.

Power, development, storage and transmission: principles of thermodynamics; essential features of construction and operation of steam, air and gas engines, especially pumping engines; distribution of power; outline as to principles and machinery for generation of electrical energy and its most important applications; also development of compressed air systems. One machine drawing. 40 half days. This course would be amplified for the M.E. division and the following course abridged.

Roads, Railroads and Transportation, as to the general principles of economic location, construction and operation, and maintenance and administration. In many important features this is a primary subject, especially as to the great body of accumulated data from experience, and the developments leading to present practice; but the student finds much appli-

cation of basal principles relating to materials and construction fitted to special conditions. Too much should not be attempted because one who chooses this line must take a long apprenticeship in the School of experience. 40 half days.

SECONDARY SUBJECTS.

Sanitary Engineering is primary as to the special body of facts and principles on bacteriology and resulting processes for purification of water and sewage. In structural details there are some distinctive features, but to a large degree the student meets applications of familiar principles of hydraulics and construction. 25 half days.

Municipal Engineering includes chiefly adaptations of data and practice already learned to special cases. Its peculiar science and modifications of practice may be learned to best advantage only in the city engineer's office.

Rockwork, Tunnelling and Mining.—If this large subject is considered, the most that can be attempted in the very inadequate time at command, is an outline course on economic mineralogy and geology, the principal explosives and methods of application in blasting and the two or three leading systems or methods of tunnelling.

Mining Engineering is developed into such a broad specialty in schools of mines and distinct mining courses that some would rule it out here. But the engineering student who is proficient in the *surveying* course already laid down is prepared to master the particular details of mining surveying (and the related

legal technicalities) when facing the actual conditions, and probably only then to any good purpose. As to the details of operation of mines and smelting works, which are so various, and dependent upon peculiar conditions and environment, many doubt the wisdom of attempting in the school any large course of instruction beyond thorough groundwork done in the chemical laboratory and in essential methods of assaying.

Thesis Work.—The writer's experience has proved the advantage to the student of requiring at least one well-prepared essay of about 1,600 to 2,000 words, during the first year. The topics assigned usually relate to highway construction or surveying. The essays are read and discussed before the class after criticism and correction by the instructor. This gives needed practice in literary composition and collection and study of data for a given theme, with some small opportunity for originality, much beyond that afforded by the keeping of a good note-book or the making of written reports of tests, etc., in form which is more or less prescribed. For the last year the corresponding exercise is the graduating thesis which, perhaps, has had too much emphasis laid upon it; it should be brief and, if possible, involve some original investigation on a subject of professional utility. There is no room for a large allowance of time for this work, but much can be done, little by little, by having the subject in hand throughout the year. In the final test of proficiency the work on the thesis should have secondary value compared to the results of regular examinations and of final test examinations covering essential topics of the course.

REQUIREMENTS FOR DEGREES IN ENGINEERING COURSES.

BY LINGAN S. RANDOLPH,

Professor of Mechanical Engineering, Virginia Polytechnic Institute, Blacksburg, Va.

In the following paper the writer does not attempt to solve the problem of what should be required in the engineering courses; but to point out the necessity for a solution of the problem, and to bring before the Society the importance of formulating some definite standard of minimum requirements for different degrees.

The matter is of so much importance, it seems to the writer, that a strong committee should be put in charge of it that it may be more completely and thoroughly studied. The excellent work accomplished by our committee on entrance requirements has paved the way for a full study of the subject and pointed out the best methods of procedure.

Let us first consider the different degrees which are offered. At some institutions serious objection is made to giving the degree of Civil Engineer and Mechanical Engineer, the preference being for the bachelor's degree, the professional degree being given only for professional work; at other institutions such degrees are given. A careful examination and comparison of the courses of instruction offered at these institutions leads one to believe that, in the majority of cases, the laying out of the course is the result largely

of the peculiarities or idiosyncracies of the person in charge or of those over him to whose opinion he is compelled, for material reasons, to defer.

Let us, furthermore, consider the different views which are held in regard to what degree should be given the engineer: The original degree was that of Civil Engineer: then came the Mechanical Engineer, then the Mining Engineer, and at about the same time sprang up the Sanitary, Hydraulic and Electrical Engineer. We already have the Sugar Engineer, and from present appearances, if conditions do not improve, we will be compelled to add some new letters to the alphabet that we may satisfy the demand for new titles. Of the two schools representing the extremes in practice, the first holds that the education should be on broad lines, making the man qualified to handle anything which may arise, while the second works along narrow lines and makes everything else subservient to that.

The idea of the first is that the Mechanical Engineer, for instance, should be equally capable of designing all forms of the transmission and distribution of power. That is, he should be able to say without bias, whether it was best to use compressed air, rope transmission, electricity, etc. The idea of the second seems to be that, we will say, a Mechanical Engineer, for instance, should be taught these things in regard to shafting or rope transmission, leaving the subjects of hydraulic and electric transmission to the Hydraulic and Electrical Engineer, and that in the future we should have Wire Rope Engineers, Compressed Air Engineers, etc. The many arguments on both sides

of this question need not be brought in here. Suffice it to say that there are radically different opinions on this subject, and, it seems to the writer, the peculiar province of this Society is to investigate this matter and to get from the engineers of the country an expression of opinion on the subject, for they and they alone, are best able to judge in the matter.

If either one of the above-mentioned views be taken, or even if there be a divided opinion on the subject, there are, however, certain practical requirements which should have more definite study and for which more definite standards should be set up than we now have. Let us take, for instance, the case of Kinematics. How much and what amount should be required for the different degrees? Is it advisable that the Civil Engineer work through all the various problems embraced therein, such as constructing velocity diagrams, gear teeth, cam-motions, etc.? How much should the other courses have? In one institution, with which the writer is acquainted, the subject of Thermo-Dynamics is handled in this way; Civil Engineers get none; Electrical Engineers get engines and boilers alone, with perhaps a little compressed air; Mechanical Engineers get all that can be put in them in the whole year of three hours per week, including gas and gasoline engines, compressed air work, hot air engines and refrigeration. This adjustment is made to fit the school schedule somewhat, and is also based upon the opinion of the professor in charge, checked by consultation with one or two engineering friends. But is it advisable and is it the best use of the students' time?

Again, the writer is aware of instances where the degree of Mechanical Engineer has been given when the only instruction in thermo-dynamics consisted of the most elementary work in the steam engine, with nothing of compressed air, refrigeration, or gas engines. The degree of Civil Engineer has been given in more than one case when the only work on bridges was the construction of one or two small strain sheets, which were not even checked by graphical methods. Such instances could be multiplied *ad libitum*, and the writer is sure that there are but few members of the Society who are not aware of similar cases.

The value of a definitely formulated set of requirements for these degrees may be briefly stated as follows:

It would permit the professor in charge of the course to have a definite guide, or a concise expression of opinion by which to be guided, in formulating his course of instruction. It would enable him to say that such and such a minimum should be required; and would enable him to definitely state to the authorities of the institution what the standard requirements were and the basis and authority for the same. He would also be enabled to call attention to those institutions whose curricula did not meet the required standard. As precedents for such action, we have but to turn to the action of the medical and legal professions, where the requirements of the young practitioner are fixed by law. That the engineering profession should take as high a stand need not be discussed here, as it is fully recognized as one of the learned professions.

The writer is aware, also, that this question should be taken up, not by this Society alone, but by the other Associations of Engineers. It should be fully discussed and approved by them, and if possible, committees should be appointed from such associations, in order to secure concerted action.

The writer has felt deeply the necessity for some such work, and feels that if it could be carried on in the same successful way as the work of our Committee on Entrance Requirements, and possibly by them, this Society would be taking one step further in the fulfillment of its duty to the engineering profession and to the country at large.

Discussion of the Preceding Three Papers.

Professor McNair.—This so-called Chicago method was in operation at the Michigan School of Mines, before it was established at the University of Chicago. It has been in operation there for at least twelve years; and it is regarded as not only practicable but as decidedly successful. The ordinary 12-term engineering course is given and put within the limits of three calendar years. That school is, of course, more fortunately situated in regard to climate than some of the rest in this country. The summer climate about Lake Superior is of such a nature that mental work can be carried on without great difficulty. However, the scheme adopted is to concentrate into the summer period, beginning in the early part of June and running until about the first of September, the field and laboratory "practice courses," and work of that sort, so that the student gets a change from the lecture room

into the shops or the field, and the change amounts, so far as he is concerned, to a sort of vacation. Now, with regard to the instructors, it has been found possible to arrange that each shall have his two or three months' rest during the year—a thing that the speaker agrees is absolutely necessary for the instructor. His work does not change in character as does that of the student. The speaker objects to calling this arrangement in an engineering college the Chicago method, but he would assert that, under certain conditions, such as those at the Michigan School of Mines, it is practicable to get the ordinary engineering course within three calendar years.

Professor Morgan Brooks.—The speaker wishes to call attention to the difference in character between commerical work and college work. He has had a great deal of experience in commercial work previous to taking up college work and got along very successfully with two weeks' vacation in commercial work and sometimes even with one week or none at all, but he found that in college work one needs more of a rest or vacation. At the same time he thinks it is quite true that with most professors a three months' vacation is not all by any means actual vacation. One may be arranging for work for the next year or studying up some particular subject in which continuous time is very necessary and which can only be obtained during the so-called vacation.

In regard to Professor Raymond's proposition to separate the students into small groups for individual instruction to the exclusion of class-room work, it should be remembered that there has been a good

deal of feeling throughout the United States that the public schools have been much more successful than private ones, simply because the work is carried on in large classes rather than as individual work. That is, in the case of individual work, some student who may not be so bright as others, gets the idea that he is the most successful of the class because he is the only one there, and he does not realize his limitations as when he is brought in contact with others, or rubs up against them, as they say, in class-room work.

Furthermore, students are apt to discuss matters outside of the class-room when they are brought together, and thus to correct misunderstandings that might remain if the work were done separately by the students. That is one of the objections which may properly be made against the correspondence schools. Some misunderstanding may arise which may never be corrected, while it would almost certainly be corrected in class-room work; not necessarily in the class-room, but by reason of the students mingling outside of the class.

Professor Merriman.—In Professor Raymond's paper the subjects and the number of hours are specified and it appears that the footing is 1,650 hours, which would be about 206 days, or, say 34 weeks. According to the plan advocated by Professor Raymond, one subject is to be taken at a time and the student is to be under the charge of the instructor who tells him exactly what to do, and who sees that he acquires as thorough a mastery of the subject as possible. For instance take the theory and general practice of sanitary engineering, 50 hours; the student

is to work eight hours per day, under instructors, studying the theory and making the drawing and computations; that amounts to six days. Now the speaker asks the opinion of this meeting as to the degree of knowledge which would be acquired by a young man who begins on Monday morning with the theory and practice of sanitary engineering and completes the same on Saturday night. Is that sufficient to entitle him to the bachelor's degree in engineering? A similar criticism can be applied to almost every subject that is included in the paper of Professor Raymond, with the possible exceptions of surveying field work and drawing. It is understood, although it is not specifically stated, that these are minimum requirements for the degree. It appears to the speaker that the minimum is put altogether too low.

PROFESSOR J. B. JOHNSON.—I am one of those more self-satisfied individuals on whom the reader of the first of these three papers chooses to look down with something akin to contempt. But I think, on the whole, we are doing very well, and one of the objects of these meetings should be encouragement and congratulation. I believe we are doing better than anybody else in the world in this line of technical education. I feel that I know we are doing the best work along higher technical educational lines that is done in the world. Now let us not be too ready to throw away the ladder by which we have climbed, to kick it down and then try to fly. It is felt that the time of our students is over-monopolized now by the instructional force; they have no time in which to

browse; they have no time to graze; they can seldom go to the library. In Wisconsin we have a new $600,000 library building, filled with books, and the engineering students are comparative strangers to it; they seldom have any time to go there; we have used up all their time; and now Professor Raymond would like to take their time for sleep and recreation and even their summer vacations. Most engineering students now find practical work during the summer vacations and thereby are able to mix together theory and practice during the same years, which is the ideal combination and the ideal method of instruction (applause), and there is no better way to do it. You are obliged to give all schooling separately if you run it the year round. In these flush times, at any rate, engineering students of all classes who wish vacation work can get it, and that of a valuable kind, so I think we are pretty well off as we are.

Mr. Kent.—When there is general satisfaction then it is time to make an advance, seems to be Mr. Raymond's statement. When that state of things exists the advance is usually made by one man, not by a whole society or by a whole community. There is some man who has an idea that possesses him and he gets other people inoculated with it, and Professor Raymond's business now is to get the millionaire to found a school which shall carry out his ideas. Professor Higgins, of Worcester, recently brought before the mechanical engineers an idea of a school of an entirely different nature and the only trouble with that idea is that he hasn't got someone who is a millionaire to found a school to let him try his ideas. It is

thought generally that advances in education and in all other branches of industrial work come in that way, that someone tries a thing that was not suggested before. That is the history of manual training in the United States; it didn't go ahead until there were enough intelligent citizens in St. Louis to give Professor Woodward a chance to carry out his ideas. That will be the way if there are reforms to be carried on in technical education. But there may be such a thing as failure; Professor Raymond's plan may not succeed.

What is to be the end of this idea of shortening the time of the engineering student to three years in order that he may graduate at 20 instead of 21 or at 21 instead of 22? Is it so important that the young man be thrust into active life so early or is it to economize the cost of the college to the trustees so that they can give an education to more people, or what is it? The speaker has not been able to learn. If it is for the benefit of the student he would say that it is in the wrong direction; that generally the older the student is taken in and the older he is when he graduates the better engineer he will be. The speaker entirely agrees with Professor Johnson with reference to the over-monopolizing of the time of the students. If any reforms are to be taken into consideration by the engineering professors, it is this: How much of the instruction can be cut out, for instance, in descriptive geometry, in mathematics, and some of the other studies which take a tremendous amount of the time of the student and which do not seem to give a full return for the amount of time they take.

Professor C. M. Woodward.—In regard to the attempt to shorten the course and to condense the instruction into a few days, it seems that Professor Raymond is exactly on the wrong track. The speaker is very fond of extending the course. His special department is that of advanced mathematics and applied mechanics. He spreads out his mechanics over two and one half years in order that it may be laid on thin so as to soak in; in order that the students may browse around, as Professor Johnson says, and see applications of it all the time. The speaker would be very sorry indeed if instead of three recitations or three lectures a week he were obliged to give five and so dispose of the matter early in the course. It would be very unfortunate indeed for the students, in as much as that work is kept in touch with the other work all the way through their professional course. This attempt to crowd things is the worst kind of cramming. At Andover, a school that prepared for college, they studied Latin at one time continuously from Monday morning until Saturday night; the students had 15 recitations in Latin a week and only on Saturday morning did they have anything else. No matter how good the subject may be, no matter how well it is presented, no matter how admirable the equipment may be, the student tires of it if it is overdone. Take shop work for example; some would put students into the shop and keep them there five or six and even eight hours a day. It is a flagrant waste of time. That is where the waste of time comes, gentlemen, in prolonging an exercise too far and in having exercises too frequently. One can hold the keen, lively atten-

tion of a student on a subject for a certain length of time proportioned to his age, his maturity and power of endurance; but when the limit of keen attention is reached, then stop; educationally it is a failure from that time on.

The speaker had the impression that the summer term was originally established for the benefit of those who were teaching or were otherwise engaged during nine months in the year. He supposed that at the Chicago University the attendance during the summer was largely an entirely new set of people who came there to get a term's work, a term of college work, and that at the end of the term in September went back to their places. Thus they achieve every year one step in a college course. He also supposed that it was specially for mature students, for men who go to college very late and who have the power of giving continuous attention to their studies for twelve months. For the normal student who enters college or an engineering school at the normal age of about 18, it seems that there ought to be a complete change involving pleasure and relaxation at least three months during every year. If a summer term is introduced let there be a different set of professors, a rotation. The speaker believes in four terms per year but not for the same student or for the same professor.

Professor Randolph.—In regard to the four-term year the speaker does not see how the professor or student could possibly stand it. He has in mind a set of young men who go to their first class at half-past eight; they have an hour in the middle of the day for drill, as they must have exercise, then an

hour for dinner and they stop at half-past four. The speaker goes around the barracks at night very frequently at 10 or 11 o'clock, and finds them working; fully seventy per cent. of the men do not stop work until 11 o'clock at night, which makes in all about 11 or 12 hours. When a man is required to do that every day in the year, he will break down. Professor Brooks has spoken of having, when in commercial life, ten days or two weeks vacation in a year. It is true but the man in commercial life generally shuts down at 6 o'clock and goes home and that is the end of it for that day. Furthermore, if he wants to get a rest he takes a long trip of a day or two on a sleeping car or boat. The speaker had the same experience and he found that he could get along very nicely on ten days' or two weeks' vacation, and sometimes no vacation at all. But he was not working all the time on ten to twelve hours per day on the same subject.

Professor Raymond overlooks one of the most clearly demonstrated mental phenomena; that is, unconscious cerebration. The speaker finds in his own work that if he studies the same subject for two or three days or a week it becomes badly muddled. Dropping the work for a time and coming back perhaps a week latter clears it up. Our mind works on when one is asleep, or unconsciously.

Professor Merriman referred to taking a course in six days. It does not seem possible for a man to get much out of it. Subjects which are very obscure to begin with come clearer to the man later on; without any effort his mind has unconsciously settled it. The main thing, brought out in the paper and mentioned

by Mr. Kent, is to settle how far to go in any subject for instance, in descriptive geometry. At the Virginia Polytechnic Institute the work is carried through the intersection of solids. That is as far as it is thought wise to go. Perspective is a very nice thing but it is not touched. Is it necessary for the mechanical engineer? The speaker does not think so. In his practice he has had to make five or six perspective drawings in twenty years, that is all. Are warped surfaces worth considering? The question is, How far shall a course go? Again there are a certain set of men in the world, whom one runs across, calling themselves engineers. The speaker has in mind a case where he was called in consultation during the last year or two, referring to a hydraulic plant. It was estimated that there was available a thousand horse-power and the question was as to whether eight hundred horse-power could be delivered electrically eight miles away. A man whom the speaker knew had measured the power. On inquiry, it was found that the so-called engineer had set up his level and had measured the altitude at ordinary high water at the top of a ripple and at the bottom of the ripple and somehow he had computed the amount of water flowing over that ripple. How it was done was not discovered. The speaker measured the flow by means of floats and obtained as a maximum about 60 horse-power. Now such engineers (?) are floating around, and it seems as though the line should be drawn very decidedly between them and men who are engineers and have worked for such titles. Many of these men have behind them the backing of a college course.

Such courses are given in this country in institutions which are giving the degree of mechanical engineer and civil engineer. The ordinary manual training school course would more nearly cover the actual work done. They have the same right to give such a degree as an ordinary manual training school. This Society should definitely decide some standard for the product or output of engineering colleges, to which standard everything must come in order to get the proper title of civil or mechanical engineer, etc.

PROFESSOR D. C. JACKSON.—Professor Raymond has done a very good thing in bringing out this discussion, although the speaker does not agree with Professor Johnson in the proposition that the theory of the paper may be correct. One may justly assert that Professor Raymond will not come here next year and support his proposal, because it is theoretically incorrect. The plan might be made to work, but that need not be discussed at all. The question to be discussed is whether one can teach to the best advantage on the plan proposed. All teachers of engineering are feeling their way, to a large extent; especially is this true in mechanical engineering and electrical engineering. Every apparent improvement is seized and tried, and adopted if it really is successful. Thus we are moving ahead.

There are two reasons that make Mr. Raymond's proposals improper. The speaker will illustrate one of them, which is the limitation of the physical and mental strength of the students. The speaker has perhaps through the senior year the heaviest work of the men in the electrical engineering course at the Un-

versity of Wisconsin. Toward the end of the year he is virtually forced, as a matter of humanity, to relieve the pressure upon those men because they come up with pale faces and the greatest evidences of overwork. They have been working each year, perhaps 36 weeks, with two or three weeks out at Christmas and a few days out at Easter and Thanksgiving; they have worked from early morning till late at night. To go on with these students each year, pressing them through the summer, at the pace they have been pushed during the winter would utterly wreck their constitutions. To do so is therefore improper and impossible, practically and theoretically.

But this might be done. The college year might be extended, the number of hours of required work being reduced so as to carry on the same amount of work through a larger number of weeks. In that case two complementary propositions enter; which shall be accepted? Shall we accept the present method of pouring work into the men for, say, two-thirds or three-fourths of the year and letting it soak for the rest of the time, or shall they be given a milder bath through the whole year which is permitted to soak as they go along? Each of these proposals has advantages, and it is doubtful if one is better than the other. It is certainly not justifiable, however, to try to give more instruction to the students in a year than they are now getting.

The second error in the theory that Professor Raymond advancs lies in his proposal to take each subject by itself and teach it alone for a short period. All the masters of the art of teaching say that when a child's mind is immature, one should begin instruction

with one subject, teach him that subject in such a way that it is connected with the things that he already knows by his observation, get him interested and carry him along, and then gradually pick up other subjects and as the mind becomes more mature the subjects should be carried along in conjunction side by side. In that way the best results in teaching are obtained. That is a proposition in theoretical pedagogy that has been demonstrated over and over again to be right, in the schools of this country and the schools of Europe, so that it is not necessary for us even to here discuss its truth. It is believed that when Professor Raymond begins to consider the matter from this standpoint he will agree that his view is theoretically and fundamentally wrong, and though his plan may be made to work it cannot result in advantage. That is, he might arrange to teach his way, but he would not obtain improved results because the plan is theoretically and fundamentally wrong.

The speaker would not object to a short summer term for his students, but he would object seriously if there was anything placed in that short summer term except the more specifically manual matters, such as a little surveying and some shop work, for instance. The speaker is willing to adopt everything that seems to be theoretically and practically right but he does not propose to be led into the belief that everything that sounds revolutionary must be right even when it is out of accord with good theory.

As to the question of degrees he does not think that is so serious a matter. He thinks the degree of bachelor of science ought to be given at the end of

the engineering courses as a baccalaureate degree because that links the engineering graduates with other educated men in science. They are as well educated when graduating from an engineering course at a proper time as they are when graduating from the science course of any of the colleges. If professional degrees are given, whether at graduation or later, the choice between them is a matter of comparative indifference.

PROFESSOR RAYMOND.—Most of those who have spokėn have done so apparently with a misconception of what was intended. It is regretted that the paper was not clearer. Answering some of the points made, it may be said that most of the speakers have undertaken to discuss what is now given by them—a specialized course—whereas, this paper presents an entirely different thing—a generalized course—and the ideas that are advanced in the paper are based on the course that is presented by the paper and not on a specialized course.

So far as the working of the plan is concerned continuous work by either the professor or the student is not necessary. The professor may have as much vacation as is indeed, although it is thought he now has perhaps more than is needed; the student may have as much as is needed; he simply works more or less continuously until he gets through; he enters at some time and graduates when he finishes the precribed course.

As to private versus public schools, the difference is not due to class work as against individual work at all. It is due to something else. Those present may perhaps all know pretty nearly what it is. Some pri-

vate schools are just as good and better than public schools; others are not. The fault in the poorer schools is not that they work with the individual rather than with large classes.

As to the number of hours required to give the minimum amount that is thought to be necessary in any subject, Professor Merriman has gone a little astray. The time should be three times what he has indicated, as it is expressly stated that one hour's count stands for three actual hours. The student then would put about eighteen days instead of six into the subject of sanitary engineering. It is generally known perhaps that the subject of sanitary engineering, after being divested of the principles which will be taught in hydraulics and in other instruction departments, amounts to very little indeed; that is, so far as the time necessary to give it is concerned.

As to the time being over-monopolized by the instructors, that is very largely true, but it is the fault of the arrangement of the schedule and not the fault of the amount of work given. And again attention must be called to the fact that this is a general course and not a specialized course. The student, as I stated a moment ago, loses fully half the time spent in class-room work. Of course, with some instructors that is not true, but it is believed to be so with the majority.

As to what the end of this is—answering Mr. Kent's question—really the end hoped for from such a scheme is that there would be more mature students in the school and that more frequently they would secure a general culture training before the professional training was taken up. As it is now, the student who

wishes that sort of a training, must take probably seven years at least of college work. In the method outlined he may complete his work in much less time, which fact will induce more of such men to take the engineering courses.

In regard to keeping at one subject all the time not being a good plan—it has been done in the Rensselaer Polytechnic Institute just so nearly as possible; it cannot be done entirely because the teaching force will not permit it, and while the graduates of this school may have some faults, it is generally well known that they have not been found wanting in their profession.

As to what Professor Randolph has said about overworking the student, again he is taking a specialized course and his students are made to recite all day and study all night. That is not desired. They should work eight hours a day only and work under instructors all the time. Of course, they may work more; those who are able to work more will do so, and those who are unable to do so much may stop short. And this perhaps answers Professor Jackson's criticism, that the student is used up with the present school year; that he could not go on through the twelve months of the year. Please remember that this course covers only two years; that is all the time the student must follow such a plan, and it is not a specialized course. Such a course in electricity, for instance, as Professor Jackson teaches to his electrical engineers would not be given. Economy of the student's time, fewer hours a day and more days in the year is the scheme of this paper.

SOME PRESENT TENDENCIES IN HIGHER TECHNICAL EDUCATION.

BY JOHN B. JOHNSON,

Dean of the College of Mechanics and Engineering, University of Wisconsin, Madison, Wis.

[The following extracts from a paper of wider scope, which was prepared for the 1901 Convocation of the Regents of the State of New York, were read by the author at the request of the Committee on Program. —Editors.]

By higher technical education is here meant that education which concerns itself primarily with the higher applications of the physical sciences to the requirements of the new manufacturing and commercial worlds as well as to the material demands of modern life, and commonly called Engineering Education. Evidently the facts and principles of science cannot be applied until they are known and fully understood. This higher technical education, therefore, must begin with a study of the physical sciences. Here we find the most important to be mathematics, mechanics, physics and chemistry. All these must be studied qualitatively to fix in the mind certain basal principles, and quantitively to establish the laws of their operation.

Thus mathematics, including higher algebra, plane and solid geometry, trigonometry, analytical geometry, and the differential and integral calculus must all be mastered in a way to enable them to be used as tools

of investigation, and not merely examined as interesting processes of reasoning. The engineer uses all these branches of mathematics as a carpenter uses his tools. The student who studies these subjects as ends in themselves, and never makes practical use of them may be likened unto a student of carpentry who simply studies the form, size, weight, material, and manner of construction of the tools of his trade but never uses one of them in actual service. The experienced carpenter would tell you he knows nothing about these implements as tools. He knows them only partially and as final products. So with the man who studies the various branches of mathematics as ends, and never uses them as tools. The man who studies algebra and the calculus as ends, knows no adequate reason for their existence, to say nothing of realizing their significance and importance. When, however, he finds these and the other branches of his mathematics are as so many effective instruments with which to hew his way through the maze of mechanical problems which beset his pathway, both in the later years of his college course and ever after in his professional practice, they become a fixed part of his mental furniture, a language in which clear ideas are expressed and conveyed with absolute accuracy and exactness, a universal solvent of involved puzzles, an equal necessity in both analysis and synthesis, the sole reliance in deriving laws from observed facts, and of predicting effects from given causes.

In short, these branches of mathematics are to the problems in engineering what the alphabet and the vocabulary are to the literature of a language. The

engineer feels, therefore, that the study of mathematics as an end is like the study of the alphabet and of the vocabulary of a language would be without ever using this knowledge in the study of the literature and in speech and in written composition of which these are but the tools. It is no wonder a study of the calculus is so often branded as unprofitable, for the charge comes from the men who have never learned to make any use of this knowledge. And it is as reasonable to set men to teach young apprentices about tools who have never used a tool in their lives, but have simply examined, analyzed, and handled them, as to set men to teach mathematics to engineering students who have never had to make practical use of their mathematical knowledge. This is the position taken by the Society for the Promotion of Engineering Education, but the mills of the Educational Gods grind slowly. In our universities the mathematics are naturally taught in the literary department and the teachers are the products of the literary and pure science courses. The difficulty lies in the great dearth of men who, having been taught to use their various branches of mathematics, are willing to engage in teaching them. If they teach at all they insist on teaching the application of science rather than the sciences themselves.

While there is a surplus of teachers of the pure sciences there is a great dearth of competent teachers of the applied sciences. The time is ripe for men to prepare themselves expressly to teach in the engineering colleges. The teachers in these colleges should have a liberal literary education, should have taken a

regular course in one of our leading engineering schools, either as an undergraduate or as a graduate student, should be able to read both French and German technical literature, and finally should have had several years of actual professional experience. A year or two spent in a German engineering school would be valuable rather as giving an easy familiarity with German technical literature than as securing a kind of instruction not accessible at home.

It is now commonly acknowledged by the German professors in the schools of engineering, that American engineering students have little to gain in going abroad except in the matter of acquiring one or more foreign languages. Indeed, in the practical application of scientific knowledge, in our shops and laboratories, we have a great advantage over them. Here we undertake, so far as possible, to let the student find for himself in the laboratory a practical embodiment and illustration of every fact, law, and principle, given to him in the class-room. This gives him a practical command of his scientific knowledge, and makes of it a working rather than an idle professional capital. In this particular the German schools of engineering are far behind us. They are now awaking to their needs but they find great difficulty in remedying their defects. There it is the theory of the school that the professor knows everything and the student knows nothing except what the professor reveals to him. Now the theory of a college laboratory rests on the assumption that the student can find out some things for himself. As this strikes at the very foundation of their system of paternalism, in both school and state,

the method is not likely to make rapid progress. It is true that in physics and chemistry, and in other pure sciences, the laboratory method is there fully developed, but it has made very little headway as yet in the engineering colleges. The great testing laboratories carried on in conjunction with the schools at Berlin, Munich, and Zurich, are all state laboratories, in which the professor in charge makes investigations, or tests materials for citizens, as we do in our government station at Watertown Arsenal, Massachusetts. The students get no practice in these great laboratories.

Returning now to the subject of teaching pure science to engineering students, the same strictures may be passed on the teaching of physics and chemistry to such students, as were expressed on the teaching of mathematics. These subjects should be taught quantitatively, and the emphasis placed on the more important portions. To be able to do this the instructor must known something of the applications to be made in engineering practice of the facts and principles which he sets himself to expound. Knowing this he can distinguish between that which is of vital consequence and that which is merely of passing interest, or which is merely illustrative of a general principle. Without this knowledge of the applications of his science, he teaches all subjects as of equal importance, reducing it all to a dead level of monotonous interest, with the result that the student slights it in the course, crams it up for examination, and is satisfied if he passes it without a condition. As little or no *use* of this knowledge was ever suggested during its acquisition the student's interest in it was simply theoretical

and what little remains with him he is incapable of turning to practical account. In other words, since engineering consists in making practical applications of scientific knowledge, this knowledge should be imparted by men who know something of such applications. The truth of this proposition would seem to be self-evident. And yet a large part of the science taught in our engineering colleges is imparted by men who know little or nothing of the uses this knowledge is to be put to by their students later in their course, to say nothing of their subsequent professional practice.

In our universities and mixed colleges, the engineering faculty commonly has no control over the science departments. At the University of Wisconsin all those who give instruction to engineering students now form a separate and independent faculty, under the Dean of the College of Engineering, and while many professors and instructors belong also to the literary faculty the character of the instruction given to engineering students is now well under the control of the technical members of the engineering faculty. This I consider an essential condition, and it is one of the tendencies of this kind of education. Many of our pure science friends feel that this too-frequent reference to the uses of scientific knowledge and laws degrades both the subject and the professor. On the contrary the teachers of engineering claim it lends vitality and interest to the subject, especially for engineering students, and it saves the professor from fossilizing on the one hand and from comet-chasing on the other. We must not forget that for the engineer science is but a tool and not the final product.

I must not be understood as saying that the engineer is a mere user of tools. He is of necessity a scientific investigator. He should be taught the scientific methods of experimentation throughout his entire course, while studying the pure sciences as well as in their applications. In fact his most valuable college acquisition is his having learned how to learn. Since the engineer stands in the community as one to be consulted in the solution of new material problems, and since he only is performing his proper social function when he can solve such new problems safely and economically, it is patent that he must be a trained experimenter in order that, by a series of laboratory trials, he may master the unknown features of his problem before he begins to embody his ideas in expensive full-sized constructions. And this a good engineer always does.

In teaching the various applications of science in the several courses in the college of engineering, the schools naturally select those which are at once of prime importance in practice and which submit themselves most readily to class-room analysis and to laboratory verification. Here also the professor must hold closely to general principles of universal application, rather than to particular facts of local or of temporary interest. While the principles of economic design should pervade all his teaching, the ruling market prices for the given place and time can well be ignored. Economy of construction is now so universally recognized as fundamental in this country that the schools are not likely to err longer in the direction of ignoring it, as they doubtless formerly did.

But since all cost is finally a matter of kind of material and of quantity of labor, these may be fully covered without consulting the prices of materials in the daily market reports.

Aside from the study of the pure sciences and their applications to the various lines of engineering practice, our leading engineering schools give considerable attention to language. A reading knowledge of German and French is essential to one who wishes to avail himself of the current technical literature of those countries, and a correct and free use of the English language in both conversation and in composition is essential to any pronounced success amongst one's fellowmen. It is very difficult to obtain all these language requirements as a condition of entrance so that a considerable amount of language work is still done in the engineering colleges. Cornell University does now make this demand upon the secondary schools, and I believe with entire success, and the other leading schools of engineering will doubtless follow suit as rapidly as they can bring their preparatory schools up to this standard.

With the rapid increase in both scientific knowledge and in its applications the field of instruction in the colleges of engineering is rapidly expanding As it seems unwise to prolong the college period beyond the traditional four years, the only solution of the problem lies in the continual differentiation of the work into special courses. This means, of necessity, a narrowing of the field of instruction. To prevent this as far as possible, the schools are now offering short or introductory courses in collateral and allied

technical subjects while giving thorough courses, both theoretical and practical, in the special field selected. This tendency is now very pronounced in nearly all our leading schools of engineering. It is only practicable, however, where all the engineering work is grouped under one faculty and where there is a helpful and compliant disposition manifested by the professors towards the work of the other courses.

Concerning the anomalous position of our colleges of engineering when regarded either as professional or as undergraduate schools, in that they undertake to be both at once, I can only say I can see little tendency to change this situation. Doubtless we will have an increasing number of students in the colleges of engineering who have completed a part or all of a literary college course, but I see no prospect of this ever becoming an essential requirement, as it seems likely to become in law, in theology, in medicine, in teaching, in journalism, and in literature. The work of the literary college must be divided roughly into science, language, and the humanities. The science and the language (modern) the engineer *must* have, and the humanities he *ought* to have. But engineering differs from all the other learned professions in this, that his working world consists in the materials, the laws, and the forces of nature. His is the inanimate world, the world of dead matter. All other learned professions have to do primarily with men and the interests and institutions of men. Studies in the humanities, therefore, are to them of the very essence of a sound preparation for their professional practice. To the engineer these are incidents, and tributary only.

Evidently any man is a better citizen and neighbor, and a more agreeable companion who has this kind of culture, and there is no doubt whatever that this culture would contribute largely to the worldly success of any engineer, whatever his professional abilities in his own world of matter, but it cannot be affirmed that this kind of culture would materially assist him in working out his technical problems. His bridges probably would be no safer, his engines no more powerful or economical, his electric devices no more occult or omnipotent. So far as serving society in his professional capacity, therefore, these humanitarian studies are not essential, and hence society cannot and will not demand them of him. In the engineer's personal interest they are essential, but of this he must be his own judge. Naturally he does not see this necessity until it is forever too late for him, except by private study. In this way he can very largely supply this lack, and many engineers do so. Many more would do so if their professional duties were not so exacting. It would seem, therefore, that colleges of engineering will always continue to remain at once both undergraduate and professional schools, and we might as well adjust ourselves first as last to this situation. This being the case, it is evident that the intimate coöperation of undergraduate schools of engineering with schools of letters and science, now found in the American universities, is a normal, a wholesome, and an economical one, and not a subject of legitimate criticism.

Discussion.

Professor J. B. Johnson.—As a piece of information pertinent to the subject matter of this paper, and which is probably of interest to those present, the liberty will be taken of talking a little about the report of the conference committee on the Carnegie Technical Schools of Pittsburg. Most of you know that there was a committe of conference called to assist the local committee in Pittsburg to outline a school for the great Carnegie fund, some twenty or twenty-five millions of dollars. The committee consisted of Dr. R. H. Thurston, Professor V. C. Alderson, Professor Thomas Gray, and the speaker. The committee met there some two months ago and were shown over the ground. They were each asked to write a separate report embodying their several ideas as to what should be undertaken. This was done and the committee came together last Monday and consolidated these four into one report. Three kinds of schools were proposed: a school of college grade; one of a high school grade, and what is called the day and evening classes, of an industrial character, which are open to everybody. A separate report was made upon the financial phases of the subject.

The report on the educational features is as follows:

Report of the Advisory Committee on the Carnegie Technical Schools of Pittsburg.

Pittsburg, Pa., June 25, 1901.

Mr. William McConway, Chairman Committee on Plan and Scope.

Dear Sir.—Your Advisory Committee begs leave

to submit the following report upon the scope of the proposed Carnegie School of Technology.

INTRODUCTION.

It has become clear, both to educators and to business men, that the new century demands a wide dissemination of a *new type of school training*. The new methods of concentrated capital and of wholesale production; the ready means of transport by which our antipodes have become both our customers and our sources of supply; the practical abandonment of both the apprenticeship system and of the individul manufacturer; the world-wide field of operations in all lines of trade; the infinite number of applications of scientific knowledge in all fields of modern industry; the whole-world competition which confines success to the most economic production; and the constant supplanting of manual labor and man power by automatic machinery and by steam or electric power; these are some of the signs of the times by which it is clear that some new kind of preparation for the work of life must be introduced into the school training of both boys and girls. This, too, not only for their individual success, but for the maintenance of American leadership in manufacturing and commerce. What this new education should be for America may be exemplified by the proposed Carnegie Technical Schools of Pittsburg. Nothing short of such a complete system should be planned.

The scheme which your committee proposes may be divided as follows:

I. The Carnegie Technical College.

II. The Carnegie Technical High School.
III. The Carnegie Artisan Day and Evening Classes.

I. The Carnegie Technical College.

This should be a first-grade technical college, superposed upon a high-school curriculum, with entrance requirements equal to those demanded by the best grade of existing colleges of engineering. It should be a school of both pure and applied science, and should prepare young men for leadership in the commerical as well as in the industrial pursuits. Both our manufacturing industries and our foreign commerce are now demanding the highest technical training it is possible to bestow, but this training must be fitted to particular vocations.

This college should be made attractive to greatest scholars in the fields of physical and chemical science. To obtain and hold such men they must be given ample opportunities for research. This college must be supplied, therefore, not only with great experimental shops and laboratories for students' use, but in all departments there should be splendidly equipped laboratories of investigation and research, under the direction of the head of such department, and with a full corps of assistants for the carrying on of lines of investigation which are now partly or wholly unprovided for in America. These well-equipped workshops and these experimental and research laboratories would form the chief distinction of this technical college, and they would also be the chief item of expense. This college would support one or more publications in which the fruits of this research de-

partment would be given freely to the world. While the number of students in this college would be small, as compared with the number in the technical high school, the work done here would be of far more benefit to the world, and it would form the chief, if not the only, feature of the whole scheme to attract attention and to extend its beneficent influence beyond the immediate vicinity of Pittsburg.

Instruction in the Technical College should include:

1. Technical courses in—
   (*a*) Mechanical engineering.
   (*b*) Electrical engineering.
   (*c*) Civil engineering.
   (*d*) Chemical engineering.
   (*e*) Electro-chemical engineering.
   (*f*) Marine engineering.
   (*g*) Railway engineering.
   (*h*) Sanitary engineering.
   (*i*) Mining engineering and metallurgy.
   (*j*) Architecture.
   (*k*) Commerce and transportation.
2. Courses in pure and applied sciences.
   (*a*) Mathematics.
   (*b*) Physics.
   (*c*) Chemistry.
   (*d*) Biology.
   (*e*) Geology.
   (*f*) Mineralogy.
   (*g*) Astronomy.
   (*h*) Economics.
   (*i*) Commercial geography.
3. Courses in modern languages.

(*a*) English.
(*b*) German.
(*c*) Spanish.
(*d*) French.

II. THE CARNEGIE TECHNICAL HIGH SCHOOL.

The work of this school should be superposed upon the work of the public grammar schools of Pittsburg and Allegheny. Its scope should be broad and comprehensive. The elective principle should be recognized, and graduation would depend not upon completing a prescribed curriculum, but upon completing a required number of courses, to be selected by the student under the direction of the director of the school.

In this school, the boy who wished to fit himself for industrial pursuits would find equal advantages with the boy who desired to prepare himself for professional engineering, or the girl who wished a general high school education supplemented by instruction in the home-making arts.

To make this instruction practical and fruitful of results it would be necessary to have well-equipped shops and experimental laboratories in all the courses leading toward specific employments, and these require a liberal housing, an expensive equipment and an expert direction by accomplished artisans. Such a complete school as is here proposed does not now exist in this country, but it would prove a pattern to be copied in every large city and such as the new century and the new industrial conditions demand.

Instruction should include:

1. The ordinary English high-school studies.

2. Physics, chemistry and biology, with students' laboratory practice.

3. The elements of the calculus and applied mechanics.

4. French, German and Spanish.

5. Commercial studies.

6. Domestic arts and sciences.

7. Freehand and mechanical drawing.

8. Technical studies, fitting for the industries of the locality, such as:

(*a*) Blast furnace and foundry practice.

(*b*) Glass-making.

(*c*) Brass-founding and finishing.

(*d*) Pattern-making and joinery.

(*e*) Metal-working.

(*f*) Stationary, locomotive and marine engine and boiler management.

(*g*) Light and power station management.

(*h*) Gas manufacture.

(*i*) Railroad transportation.

(*j*) Plumbing and domestic sanitation.

(*k*) Surveying.

(*l*) Clay working and ceramics.

(*m*) Industrial art.

III. The Carnegie Day and Evening Classes.

These classes are proposed for the benefit of those who are unable to take advantage of the more complete courses in the Technical High School. They should be available to both sexes. Instructions should include:

(*a*) Elementary mathematics.

(*b*) Elementary physics.

(*c*) Elementary mechanics.

(*d*) Elementary chemistry.

(*e*) Freehand and mechanical drawing.

(*f*) Modern languages and elementary instruction in such technical subjects as are taught in the Technical High School.

(*g*) Courses of special lectures on subjects of interest to artisan classes.

In conclusion your committee desires to state that in its judgment a large tract of land, not less than 50 or 60 acres in extent, should be provided, in order that the buildings may be grouped about an attractive campus.

Furthermore, the best educational experience leads us to believe that the highest interests of these schools will be conserved by being maintained as independent institutions unhampered by public or private control.

(*Signed*) ROBERT H. THURSTON,
VICTOR C. ALDERSON,
THOMAS GRAY,
J. B. JOHNSON.

MR. KENT.—The speaker regards this paper as a splendid contribution to the literature of education. Referring to schools teaching the foundation of industrial trades the author states, "By this means we do not antagonize the trades unions." As the speaker understands it, the trades unions are opposed to the establishment of strictly trade schools. They are opposed to giving a boy an opportunity to get into a trade

except under their regulations. They do not like too many apprentices in a shop. It seems that the time has come when if the members of this Society have anything to do with the education of the future, they should set their faces as a flint against these mistaken ideas of the trades unions. It is time that they denounced, not the trades unions, but these particular features of their methods. This tendency of the trades unions and the limiting of the opportunity of the young man to get employment is regarded by the speaker as one of the great crimes against humanity. In this Carnegie school everything has been recommended that should be provided for in a school that expends half a million or more a year, except trade schools. Trade schools should be added, or at least one, or two, or three trade schools. In some lines of business trade schools have been established, such as the textile schools in Philadelphia and Lowell and Fall River. There is the Williamson Trade School in Philadelphia and the New York Trade School in New York and Girard College, one of the earliest of trade schools, and it is important for the future of America that these trade schools should be established, not in antagonism to trades unions but to give a place where a boy can acquire a knowledge of a trade if he wants to, to learn to be a stonecutter, a bricklayer, or a carpenter, or a plumber, or something of that kind. It is high time that the stand be taken that trade schools should be established for the benefit of the country at large.

Professor Johnson.—The committee were officially informed that it would never do in Pittsburgh.

Mr. Kent.—By whom?

Professor Johnson.—By the local committee.

Mr. Kent.—The committee should have had the bravery to oppose the local committee and recommend to Mr. Carnegie that in spite of this antagonism he should establish a trade school.

Professor Johnson.—It is a great question in the speaker's mind whether or not it is wise to undertake to teach the manual part of trades in an American school. It seems that this feature of the foreign trade school should not be copied.

Professor Williston.—Mr. Kent has expressed regret that the trade school was not included in the recommendations made by the advisory committee for the technical school at Pittsburg and he has referred to the Lowell Textile School, the Williamson School and the New York Trade School as though they were all schools of this type. The ideas which these three schools are carrying out differ radically and some of them are included, as the speaker understands it, in the technical high school that has just been described. The school that attempts to teach a trade, and nothing but a trade, and does not encourage its students to reason and think very much for fear that they will not long be contented working at their trade, is not included and the speaker does not feel badly to see it omitted. He agrees with Professor Johnson that the foreign trade school of this type is something which finds no place in America. All the schools in this country should be planned first of all to educate, to give to their students greater mental capacity and power and to give them added ability to reason. The more closely such education is related to the

practical problems of life the better they will be; and if besides they can cultivate in young men mechanical skill in various trades they render great help to the industrial prosperity of the community.

Several of the schools which Mr. Kent referred to are keeping these facts in mind and are devoting more time to mathematics, physics, chemistry, mechanics, mechanical drawing and similar subjects, than they are to the practical instruction. They teach trades much in the same sense that the engineering colleges do, and they teach them to young men who are going to put them into practice. But these schools are something more than trade schools, as the speaker understands the use of that term. The trade school, if it be given this broad interpretation of being a school where instruction is given in trades and in a great many other things besides, is provided for in the scheme of the technical high school, and the speaker does not believe that it was a mistake to leave out the trade school of the narrower type.

In this connection the experience of the Pratt Institute may be of interest. A number of years ago when the institute was first founded after Mr. Pratt had spent several years studying foreign schools and was strongly imbued with the idea that there was a place for the German trade school in American conditions there were a number of trade courses introduced, such as those for carpenters, plumbers, machinists, bricklayers, etc., but it was gradually discovered that in order to turn out efficient mechanics who would be capable of exercising good judgment when occasion demanded, far more general intelli-

gence was required than could be imparted through shop instruction alone, and it soon became apparent that the idea underlying Professor Higgins' Half Time School, of devoting half the day to the practical instruction in the shop and the balance to subjects that tend toward a more general development, was sound.

Accordingly their trade courses as such were one by one discontinued and in their place have grown two-year technical courses which offer a large amount of practical instruction in carpentry, pattern-making, forging, foundry work and machine work, but which also offer thorough instruction in mathematics, physics, chemistry, mechanical drawing, mechanism, mechanics, electricity, steam and the steam engine, strength of materials, etc., with the corresponding laboratory courses; and it is found that the graduates from these courses make a far better success when they enter a machine shop or some other practical work than did the graduates of the former strictly trade courses, because of their greater reasoning power and of their better understanding of all their fundamental principles underlying the practical problems that they meet. And it has been found that this far more than compensates for the decreased term devoted to this practical shop instruction.

Professor Emory.—The speaker hesitates somewhat to discuss the question of the trade school because it was omitted from the report. What the author says is largely in the form of experience with trades teaching. The work of the world is done by laborers who have little education. They ought to be provided with some kind of a school. Some years

ago I had the pleasure of being invited by Col. Gardner Tufts of the Massachusetts Reformatory at Concord to establish a trade school, pure and simple. His idea was to select from the 1,200 inmates of that institution a number of men for whom some good could be done. Some of the oldest in years were the youngest in experience with work. A trades school was started consisting of a number of branches. There a half-day principle was inaugurated, that is, in the morning the men were all put into the shops, under contract labor—into the chair shops and tailor shops on general contract work; then in the afternoon, they were put into the trade schools where they worked and studied until five o'clock. If put in the brick-laying department he was made to build a wall; started on a simple wall, relaid it and used mortar over and over again until he wore it out; turned arches etc., developing slowly, turn by turn, making all the bonds—in fact he was taught, all that the best instructor knew about brick work. Then he was required to lay a number of brick in a certain time—in other words, he was given that experience which produces skill. Skill is a matter of experience, not of knowledge entirely. Then in the evening they were put into the classes in reading, writing, arithmetic; during afternoon some were given lectures, usually about a half-hour, not over that, because their attention could not be held longer.

PROFESSOR JOHNSON.—But they were not required to hold their minds?

PROFESSOR EMORY.—No, but they would hold their eyes. That was considerable, because they learn

through two channels, and one of them at least was open. The result was that, in one instance, which is perhaps the most interesting, a man of about 25 years started to learn bricklaying. After laboring with him for two and one half years, he was finally sent out. A week afterward he was earning $2.50 a day on the wall.

PROFESSOR MERRIMAN.—Where is all this?

PROFESSOR EMORY.—That was at the Massachusetts Reformatory, at Concord; similar work is done at the Elmira Reformatory by Col. Brockway. And that was a class of men who never would have amounted to anything at all; simply being an expense to the state. They were transferred into working men, revenue makers.

Now then, if one can teach that kind of stock, how much more can be done for the son of the intelligent workingman who has no opportunities to learn except what he picks up on the street?

This is a need that is not met at all. It seems important that trades teaching should be more broadly established. Our engineers develop improvements and manufacturing is done by jigs and power, men being utilized simply to guide the drill. Skilled mechanics of the old kind are fast disappearing and soon our workers will become mere machines unless more attention is given to trades teaching.

The speaker is especially pleased with the paper of Professor Johnson and was very much pleased to think that the representatives of this Society shared in the grand project of the Carnegie Institute.

PROFESSOR WILLISTON.—The speaker would like to

ask Professor Emory if the difficulty with the bricklayers that he described was not their lack of general intelligence, and lack of ability to apply what knowledge they perhaps had, rather than a lack of mechanical skill? It has been the speaker's experience that a workman with a good head on his shoulders is almost sure to be a good workman, and that without this general intelligence, no matter how much skill and dexterity he may have, he is not likely to prove very efficient.

It seems to the speaker, therefore, that what is needed in all the trade problems where it is found difficult or almost impossible to get the men that are necessary for the best and most economical production, is more brains rather than more manual skill. The only way in which the present condition can be improved is through more education of a kind which the young men who are going to enter the various trades can make practical use of, and this must be given them at an age when they are receptive, that is, during the school period of life, and not after they have reached maturity, when their minds have ceased to develop and are not able to absorb new ideas and new thought.

The best results cannot be obtained through a trade school when the young men are kept at work at the bench or lathes all day, for, as Professor Woodward remarked when speaking of students of college age, time is wasted when young men are kept for five or six hours at a time on one particular line of work, since they soon reach a point where the mind has received as much as it is able to absorb of that kind of instruction.

To secure the best results the practical work should be alternated with class-room instruction in mathematics, elementary science, mechanical drawing or other similar work. The speaker is not now urging more higher education nor more engineering education, but only an intelligent application of the same kind of ideas that are used in the engineering schools in combining theory with practice for the young men in the lower grades who are going to be the mechanics of the future. He is urging a technical training which will give him the skill and dexterity that they need, but at the same time give them the general intelligence to enable them to turn their skill to the best possible advantage and, if they have the mental ability, to rise to positions where they may have the direction of important work.

PROFESSOR EMORY.—If the Professor will state that question again the speaker thinks he can answer it in a few words.

PROFESSOR WILLISTON.—The question asked was whether the difficulty with the mechanics was not largely that they did not have sufficient intelligence to direct their own work and make things come out as they ought?

PROFESSOR EMORY.—In their cases it seems a lack of proper training rather than lack of intelligence. It seems that apprentices nowadays are impressed with quantity rather than quality.

PROFESSOR D. C. JACKSON.—The speaker has been very much interested in everything he has been able to learn in regard to the plans for Mr. Carnegie's schools at Pittsburgh, inasmuch as it has seemed that

those plans apparently mean the addition to the fabric of industrial training, from its elementary branches advancing through the intermediate up to the highest education, the greatest addition to that fabric that anyone has yet dreamed of; and the speaker rejoices that Professor Johnson has placed his views so clearly and fully before the Society. As to the small details of the plans, which have been referred to by other speakers, we may rest assured that the local committee and Mr. Carnegie have the best interests of the people of Pittsburgh, and the workingmen especially, at heart, and that they will steer the ship between the difficult rocks and shoals which they must meet. All who have had anything to do with labor, recognize the fact that there are difficulties to meet. Many of them are just difficulties; some of them, perhaps, are not just difficulties, but these are often due to the frailties of human nature and the speaker does not think that Mr. Kent is justified in his assertion that this Society should oppose all the attitudes taken by trades unionism which are apparently wrong. It would be the height of error for this Society to take action upon questions so remote from its province.

When the speaker used the term trade schools in his paper, he used it rather from the standpoint of Professor Williston, the rather more advanced standard, perhaps, than that of the German and French manual trade schools.

Professor C. M. Woodward.—This discussion has drifted off a good deal to trades schools and involves really an approval of the outline in this committee's report. The speaker wants to say just a word on that

subject because it seems to be entirely in order. He approves of the omission of a trade school explicitly in the Carnegie Institute. He thinks that a better thing can be done and that the committee have recommended a better thing, which is going to meet the demand in the future, it is going to meet the demand that Mr. Kent refers to and that others refer to as coming up from the working boys, and believes that the technical high school or a manual training high school is going to solve that problem.

The speaker has had a great deal of experience in this matter and he has known the graduates of manual training schools who were the sons of workingmen, men who had to earn their living right off from the day they left school. He knows what has become of them and he knows how they have been treated and he knows how master mechanics regard them. He will simply report the testimony of Mr. Bartlett, who is the master mechanic of the Missouri Pacific Railroad, who has had a great many of these boys who have applied to him after finishing the school for work in the shop. He takes them in there as advanced apprentices and he puts them on the scale with boys who have been in the shop almost as long as those boys were in the manual training school, and he pays them as much, and that is the best possible recognition of their skill of hand and their intelligence and their adaptability and their teachability and their general usefulness. He said he would like to select every apprentice in his shop from the boys who come from the manual training school instead of the boys who come from the outside.

Now, the manual training school is not a trade school. The trades unionists do not oppose the manual training school in St. Louis or anywhere else, because the boys do not enter the school with a distinct intention of learning a particular trade, and the small amount of time that they give to the manual work is in the estimation of the trade unionist so little that it doesn't hurt him any. The consquence is that the school entirely escapes criticism and escapes opposition where it is understood and yet it is doing the work, it is doing the very work that is wanted. It is giving these boys a chance to acquire a degree of intelligence which must go with skill in hand if they are going to be first-class men, and it does open the doors of the shop to them afterwards. Hence the speaker believes that this is going to be the solution of it.

Professor Goss.—The speaker desires to express his interest in the paper which Professor Johnson has presented. It shows clearly present conditions and indicates the tendencies of our work. It is known that a man can become a tradesman without a school, because men having very little education are becoming tradesmen every day. So if one now comes forward with the trade-school proposition, it implies that some school work is to be added to the process of trade teaching which is now in vogue. What is to be done for the trade-school student during that portion of his time which is set apart for scholastic work? Shall he be given those things which, if he did not attend the school, he would be sure of finding out? Shall he be made skillful in manipulation when it is known that

his whole life is to be spent in a process which will tend to increase his skill in manipulation? The speaker does not so believe. He believes that every such man should devote every hour of the time set apart for scholastic duties to just such training as is proposed in Professor Johnson's scheme for the technical high school. That is the only thing which can do him great good. It is the one thing which as a tradesman he will not do for himself later. It is for these reasons that I am heartily in favor of just such trade schools as have been defined to us as technical high school.

ÆSTHETICS IN ENGINEERING DESIGN.

BY RUSSELL STURGIS,

Architect, Artist and Art Critic, New York City.

Professionally speaking, the architects and the engineers are not so very different. Each body of practitioners has managed to make a profession, almost a learned profession, out of what was once an art, the art of good building. Engineers and architects practiced in former days as painters and sculptors practice to-day; they were all master builders together; and those days were the days of great artistic achievement. Now that the architect has become a professional man he has very largely ceased to be an artist; or, if anyone prefers to put it the other way, now that the architect has almost ceased to regard himself as an artist, at least in the usual sense, he has become a professional man.

And yet this cannot be said with the same force and with the same universal truthfulness of the engineer as of the architect. What is the special nature of the professional man's work? It is, I suppose, the giving of advice and the exercising of a controlling influence upon the work of another. Creation is not the forte of the professional man; he may indeed create the wording of a brief or of a specification, he may compose a sermon or think out and produce a new mode of treating a difficult and complicated ailment: but in the sense in which the artist creates, in the sense in which the painter brings into existence out of nothing

a wall picture,—or the sculptor, with no material to start from but the gray matter of his brain, produces an elaborate composition in pure form, in that sense the professional man is not a producer, not a creator, not by much an artist. Still, however, the engineer is more of a creator than the architect. He has learned to use his gained knowledge of the strength of materials, their nature, their adaptability; and he has gained a special power of calculating in advance the combinations of materials necessary to produce a certain result; and then, out of the abstract he produces the concrete. He figures in advance, and his figures produce tangible and ponderable results in a way that would be artistic had he artistic subjects to deal with. The architect was creative and original in this way, in the old times; in rare instances he is so to-day—planning a building with especial reference to the site and the requirements of those who are to use the building, and creating the exterior and interior design as instinctively as he brings together the parts that make up the plan. I need not, however, insist upon the fact, known to all and the chief subject of our anxiety of mind, that in our time the originality of the architect has sadly diminished, and that the custom obtains almost universally throughout the whole architectural world of borrowing directly from the past everything that is of importance in his artistical design.

It may be thought then that if the civil engineer is more of a creator he is therefore, more of an artist than the architect. And yet we should be wrong in thinking so, because something more than originality is needed to make a man an artist. The artist is indeed

he who creates, but he is also the man who creates the artistic thing; that is to say, the thing which is calculated to please greatly the trained eye and the brain behind it, and to touch the heart of everyone who loves beauty in nature and in the works of man. To have created the Tay Bridge is, I may say, under correction, a great achievement of engineering skill, but it can hardly be called an artistic work, because nothing uglier has yet been produced by man, busied as he is in disfiguring the world he lives in. It is not necessary to go so far from home to find similar instances of deformity produced at elaborate cost of money and of engineering skill. The modern engineer is indeed an artist so far as the exercise of his creative faculty goes; but he is as far as possible from being an artist in the usual sense of the word, that is as the producer of things of external and visible charm, of things calculated to give high and enduring pleasure.

Let us consider, however, no problem so enormously difficult to deal with here as railroad bridges across estuaries; but rather the things which are simpler, the things of which there are more all around us, and those of which an architectural artist can more boldly speak. But the proper arrangement of a bridge across a broad river might seem tolerably easy for a practiced constructor if he had to build with masonry. But observe this distinction: to the artist as architect the appearance of mass and weight is of extraordinary importance, and he can hardly be supposed to understand readily or to care heartily for a structure which is entirely of slender lines which look almost like threads to his eye accustomed to abutments, to arches,

to massive piers of masonry. He has an instinct for his piers and arches. He cannot go far astray with their management. He sees the possible and the dangerous with the quick eye of habit. And here is one of the difficulties which the artistic critic of an engineering structure has to meet. The critic must try to create for himself a modification of his own acquired sense of what is fine, and must put clearly before his mind the great question whether a building composed entirely of slender uprights and ties can in itself have any beauty at all. Let it be granted that the Tay Bridge is really as ugly as it seems to me. Is this altogether because of the monstrously clumsy shapes of its separate masses, or is it partly because it has not that appearance of massiveness, of continuity, of the dignity of hugeness which even an ugly form in solid masonry, in earth work or in the piling up of stones has always been felt to possess. That monstrous cairn which we call the Great Pyramid is without architectural beauty, yet is beautiful somewhat in the way that a natural hill or bare cliff is beautiful. Its vast mass and the sense we have of that mass and of its ponderosity gives a charm which to the mind unaccustomed to analyze architectural design seems architectural; and nature invests its slopes and its wrinkled front of stone with lovely lights and soft gradations of shade, as she would treat a natural hill. But a structure as vast, as strong, as enduring as the great pyramid, built of slender bars of metal, would never seem to those brought up as we have been brought up beautiful or attractive in the same sense. It is true without doubt that the gigantic châteaux of

Pierrefonds and Coucy, the prodigious fortresses with which Syria has been beset by Romans, by Byzantines and by crusading knights are of extraordinary interest, and that though apparently built with military ideas alone, they have a charm peculiar to themselves. But is not this charm akin to that which we find in the Great Pyramid? Nobody in designing the wall-towers of Lucerne, which rise still against the summer sunset, thought of making them beautiful except in this, that the man who built them was accustomed to give graceful forms to belfries and spires of churches and his practiced hand could not be stayed—he made the towers graceful in form without conscious effort. Could he have done so, could the military-architect have made his masses either graceful or imposing had his construction been a magnified and glorified stockade of steel bars? That would have made excellent fortification, because the resistance afforded to the more heavy missile weapons of the Middle Ages would have been immeasurably great, as to ram and to pick, and the protection of life within would have been secured by very slight curtains, as of raw hide; but would it have been attractive to those men who came afterward, caring nothing for the fortress and everything for the noble and picturesque old building?

If you understand me as hopeless of the skeleton building I have failed to make my meaning clear. I think that there must be a way out of that difficulty too, but I think that we shall only find it by trying the easier problem first. That which I have to urge upon your attention is the value of tradition, and traditions are not built up in a night. I want to show

how tradition may be swayed a little, how we may help to build up a tradition to suit ourselves, and I say that we must go easy! Thus, if the buildings upon which our artistic traditions are all founded were, as they actually were, massive buildings, buildings with solid walls and continuous walls with openings but few and small in comparison to the mass of their unbroken surface, it will be well for the engineering student to consider what that tradition was and is and its value before throwing it aside and trying to design things as they have never been designed since the world began. The only tradition which we have for gratings, balustradings, combinations of bars and the like in metal is in the window guards and wrought iron gates, or at most in the solid and continuous railings which surround certain courts of entrance to great public buildings. But we have a tradition which is so strong and universal that even the most careless architectural designer acts under its continual impulse.

Parts of that tradition are these:

That a wall should look solid, and even heavy, the openings in it being evidently not too numerous or too large for its full strength.

That the openings in this wall, doors and windows, should be arranged with special care, for this penetration (as we call it) is our chief element of design: and that the wall should be crowned with so much of a projecting and undercut or correspondingly massive upright and deeply marked member as will seem sufficient to frame in and to separate from the sky the whole of this pierced and checquered wall.

That this wall may be replaced by a row of columns

or piers; but that then the space between those uprights will require a special treatment by itself; either the wall back of the colonnade showing as a separate design with or without window and door openings, or, if the space between the piers is immediately occupied as by glass, then those openings to have a special artistic treatment.

That small openings may be spanned with lintels or arches, while large openings require the arch in every case. But those arches, though it is a doubtful thing to do, may simulate lintels, a perfectly flat arch of unrecognized, unasserted voussoirs being treated as if a flat trabeation spanned the opening.

That the arch where it is large and often repeated must of necessity become a very important, perhaps the most important, feature in the design, and should therefore receive such adornment as the principal member of the structure deserves. This, however, may be given in the Roman way by flanking each arch with a pair of columns or pilasters carrying an entablature, the thing being recognized as a mere adornment but now recognized for so long a time and accepted so universally that the arch seems glorified and not humiliated by this square framework to its curved individuality.

All these and many more maxims apply to the exterior alone, or to such parts of the interior as only a very few buildings possess, namely interior faces which are like street fronts in their dignity. As for the interiors proper, the treatment of great halls with vaulting or with flat roofs, another world of maxims exists with regard to that. One hint that was given me with

regard to your wishes at this meeting was that I should draw up a scheme of study in this department which we are considering, and this contribution to such a scheme I may make assuredly—the reminder that the essence of an architect's designing, that which is universally good and universally applicable in his way of designing, is that which is founded upon these very maxims, and such as these. You see they have entered into the life of generations of architectural designers. The men of to-day design, and the men of to-morrow will be designing, not as their own instincts alone would have led them to design, but as they are bid by those instincts, developed, modified, shaped for them by years of familiarity with these maxims. The most ardent preacher of the doctrine of free design and the most convinced conservative among those who would have everything admittedly conventional would still be found to agree if their inmost minds were examined. They would agree upon such a host of essential and primary truths in design that all in which they disagreed would seem as nothing. If we could look into their hearts from an outside point, as a disembodied spirit may be supposed to, or as a very intelligent Indian Buddhist designer of carved sandstone Dagobas, or a Japanese brought up in the undisturbed tradition of his national art may be supposed to look, that is, without taking anything for granted, inquiring only what was the habit of mind of the patient, we should find that the points of agreement between conservative and radical were so numerous that their points of disagreement would seem like unimportant nothings to us outsiders. And, therefore, I say

that the basis of all study for the engineer who wishes to know why engineering buildings are so bad, and how they could be made better, is and must be an attempt to study the secret of this tradition and to revive it for himself and his fellow workers in scientific building.

There is, however, something to be offered you which may seem more practical—at least more immediately available. The tradition of which I speak takes many forms and sometimes branches into rules of conduct which seem contradictory one to another. Thus, it is a great principle of design that the structure should dictate it, that the design itself should grow out of the structure: but this undenied verity would be differently urged by a Roman master builder of the time of Trajan and a French stone mason under Saint Louis. The one would be sure that he had filled the conditions of this rule when he had made his vaulted or his trabeated building so unmistakably genuine and permanent in its character and had given it such undeniable forms of hollow, rounded roof and of colonnaded porch of entrance that no surface adornment could change it. He would be satisfied with that: and feeling so content with what he had done he would turn loose upon his building an army of decorators, caring perhaps less than those decorators themselves what coloring, what relief, what statuary might be added to his massive structure. It need hardly be said that this was not the Gothic builder's way. To the Gothic builder added decoration went no further than the colored translucent filling of his openings and the colored opaque surfacing of his deeply

moulded and strongly accentuated piers. Every nerve of his building, every secret of its structure was left visible. The thirteenth century man would not have thanked anyone who would have brought fifty thousand crowns' worth of precious marble slabs with which to line his walls, and he would probably have murdered the individual who proposed to box around his vaulting shafts so that their ribbed structure would be hidden. And the Roman, while he was not indifferent to the importance of having a vertical line lead up to the spring of his groin vault, and would even enlarge this vertical line into a gigantic monolithic shaft of red granite backed up by an equally gigantic pilaster of green porphyry, the Roman minded little what was thought about his plan of building. He was sure that that would be sufficiently obvious and he would allow the decorator and even the artist who would fain sheath his walls with precious materials—he would allow such a man full swing.

Remember that it is in the building of the Imperial Romans that all our modern work takes its rise. The artistic traditions began there. No man goes back of them except for a detail. No man begins this side of them without a consciousness that he is hailing back to the Roman period after all. The Roman Imperial engineers gave us the great interior, the vaulted and the flat-roofed hall of vast size and of permanent structure, and it is from this that our larger and more monumental modern buildings have taken rise. The Romans gave us superimposition of stories also; and this, though their own monuments have perished, has affected the whole of modern Europe and was at the

bottom of mediæval planning. It is to the Romans that is traceable our modern way of building, sometimes with pillars carrying beams, sometimes with arches and vaults, sometimes with both mixed together in a wholly illogical but not wholly unsuccessful fashion. It is to the Romans that our peculiarities are due, our good and our less good peculiarities; but for the Romans we might have derived our way of building direct from Japan and have built to this day in wood or in wooden structure copied with natural alterations in metal; and I am not eager to insist upon this being a fortunate escape either. There are fine things about Japanese construction and great possibilities of design which, unhappily, their native architects to-day refuse to follow. But for the Romans we might have drawn our architecture exclusively from Greece and have always condemned, as they did, the arch and the windowed wall and turned our backs upon the possibilities of interior effect. But for the Romans our architecture might be based upon that of the primitive northmen, and their wooden structure instead of that of the Japanese in our notions of how building should be done; their slab walls and surface carving and all the clumsiness of the far northern community trying to shut out the cold even if the light of day had to be shut out with it; that might have been our prototype. But for the Romans we might have been builders in solid stone almost monolithic in character, like the people of northern India, for there is no reason on earth why a monumental architecture might not be based upon the stone buildings of the northwest provinces, while the domestic

architecture would be based upon the wooden buildings of the same districts. There is nothing except the traditions of the Imperial administration and its servants and their followers in the whole Mediterranean world which has made the architecture of Europe since the tenth century just what it is.

Therefore, when we look at our traditions seriously, when we look them through and through, we find that those are the only traditions that are of importance.

The Romanesque men in the earlier Middle Ages did this; they were compelled to do their work cheaply and yet they desired to do what the Romans had done. Therefore, they devised a plan of building by means of stone taken out of the nearest quarry and cut into handy pieces, a round arched, groined vaulted, narrow aisled building, a building divided as it were into galleries, one-fifth or one-sixth as wide as they were long, and therefore easy to roof, and there grew up a very ingenious, attractive and interesting sculpture, based upon the combined study of the Roman past and of the simple forms of nature. And then came in the middle of the twelfth century the astonishing Gothic outburst, and Romanesque architecture suddenly sprang into lightness, height, capaciousness and a vigor of expression hitherto unknown to it. The main purposes were the same, and even the main methods of the builders were the same, with only this difference, that they had learned a little secret, had devised a new scheme of getting over the difficulties of the vaulted roof and had learned to vault even the most complicated spaces without difficulty and without costly centering, and all by the simple device of

building an arched rib and then another and another, ribs eight or nine inches thick and a foot deep, and perfectly easy to construct. The triangles between these ribs could be filled by vaulting of the simplest sort of rubble work and without centering except for little spaces at the crown of each vaulted compartment. That was the Gothic secret; and now that it is known there is no reason that we should not apply it in other styles, in any style. If we used vaulted buildings we should apply it.

Then came the Renaissance of the fifteenth century, and the fancy in men's minds that they would go back to Roman forms; when all the while they knew nothing about what the Roman forms were, and took but little pains to inquire. The Italian buildings of the first hundred years, 1420 to 1520, were not classical Roman even in a detail here and there, exception being made for the exceptions. There is here and there a Pazzi Chapel, but the same man who built that and tried to do the Roman in detail, if not in spirit, built also the Florentine palaces with long rows of equal arched windows and a mediæval sort of sculpture in their archivolts, and he built also the soaring Florentine cupola, as different as possible in essence and in appearance from that cupola which he is thought to have studied, the low-lying dome of the Pantheon at Rome. For all essential purposes the Roman tradition was just as strong in the fifteenth century as it had been in the thirteenth : just as strong and no stronger. The structure of the buildings and even their design, pursued an almost uninterrupted evolution. There was indeed a certain self-conscious-

ness, a certain deliberate casting back into antiquity, but so there had been very often before. It was only an increased power of reading Latin and Greek texts and the discovery of the manuscript of Vitruvius with its half-stated, feebly-argued, dimly-understood accounts of Roman ways of building. We are told, and it is true, that in later years, in the centuries following the epoch of the Renaissance, during all that period which we call the neoclassic period of architecture, the Roman remains were studied with more care, but they were not studied for close imitation. That is the curious part of it. Details which had been very rare among the Romans, and which, so far as fifteenth century Italian students knew, were almost unknown to the Romans—I mean the rows of pilasters, the pedestal upon which the column or pilaster was raised up one quarter of its own height above the ground, the groin vault of cut stone in which the joints were visible and the large and massive blocks of stone could be counted, the tower rising clear above all surrounding roofs and showing itself as an unobstructed shaft some hundreds of feet in height, the colossal order where a colonnade stands fifty feet in height from base to abacus and encloses within its height three or even four stories of windows which show between the shafts and contradict them, such modifications of building and of design as these were so rare among the classical Roman buildings as we know them that they may almost be said to be non-existent, and yet they are a part of the Roman inheritance. It was natural for the sixteenth century men to build in this way if they were desirous of doing the Roman thing. Archæological accuracy

was not their forte, but building was; they knew about building and they had heard of Roman dignity, and that is the way in which traditions grow up.

What then is the immediate lesson for us now that we have no longer the habit of building naturally, of building as our instincts lead us, now that we are altogether too learned to act without conscious imitation of the past, and that we are unable as it seems, absolutely unable, to agree upon any plan of decorative building so far that two designers can help one another by each man doing what his neighbor has done and trying to do it a little better or with a little variation. We can do this. We can cast back to where our traditions began and see whether there is not visible in and about the Roman origin of all our traditions a principle not perfectly observed since that time, a principle of design which the later builders of tradition upon the Roman foundation disregarded in the main because they had not that vast world-wide control of materials and of labor which the Roman builders possessed. We have that control once again; it has come to us in even greater measure than to the Imperial Roman administrators; we may be allowed to see whether a conscious modification of traditions may not be in order.

And now observe that the special device which the Romans resorted to was the device of building first and adorning afterwards. Their structures were great when they did not adorn them. Aqueduct and viaduct bridges which never were adorned, and gigantic arcaded exteriors now stripped of all their once existing beauty of color and refined surfaces are there to

show that even their simplest work has a charm now difficult to reproduce, but their purpose was to adorn their great buildings by decorative appliances added after the fact, so to speak, after the essentials of the building were completed.

Their constructive forms, without having the refinement of Greek or the spirited dash of Gothic work, are still interesting and often fine. Ours might be equally fine if we were more thoughtless about it. We have all seen modern work in masonry done by engineers without asking the help of trained designers in which the simple forms are very good indeed in their result. The cutting and tunnelling north of the Grand Central depot in New York, what we used to call the sinking of the track, is full of evidences of this, for the half round arches are well proportioned to the walls above and around them and to one another, and the simple brick wall, thick, and tied and bonded by cut granite has all the beginnings of an excellent architectural design. We could do that and better than that every time if we were not trying to imitate something in the past. The Romans imitated nothing, and not caring much, for they were not essentially an artistic race, any more than we are, produced such successful grouping, such good proportions as those of the famous Pont du Gard in the south of France, or those that we can still see at least in the mind's eye in the interiors of the Constantine basilica, the great hall of the baths of Caracalla, the Nymphæum at Nimes, and the rest. Their general constructive forms came at will, I say; they were such as would be imposing, grave and dignified, not over and above refined and yet full of a certain dignified mastery.

To this, however, there came the decorative artist and whithersoever he was wanted he brought his marble in slabs, and in heavier blocks to be wrought into relief and rounded forms; he brought his tesseræ, large ones for the floor and small ones for the vaults, and worked his mosaic in monochrome or in vivid color; he brought his tiles of glass, opaque or translucent, modelled in relief or inlaid with the most delicate and refined patterns, solid tiles of glass fit to bear a blow or a moderate settlement if such a thing could be imagined in the massive Roman wall; he brought his pigments and his gold leaf, his pencils and his brushes and pots of size, and above all things he brought his preparations for the most elaborately composed and patiently wrought hard plastering which we know. It is attractive in the dull pages of Vitruvius to read about the fine stucco so smooth that it was used for mirrors, so hard that it could be cut in slabs and treated as table tops, so interesting to the ancient collector and amateur that he would preserve slabs cut from old walls and use them anew; but then Vitruvius tells us also of three coats of lime with sand and three coats of lime with marble dust and that put upon solid brick walls and vaults as solid as they. If he had only told us how thick the coats were, how liquid the paste was made, what the Roman theory was as to its setting and as to the stirring and mixing of it!

The fact remains that the Romans built first and adorned afterwards, differing, in their simple acceptance of the principle, very widely from the Greeks before them and the Romanesque and Gothic work-

men after them. And there is every reason why the modern engineer should aim at doing the same thing. For his structure, if it is of metal, must be covered up to keep it from wet and from fire, and if it is of mortar masonry, will not be admitted to favor if its real nature shows on the surface—while cut stone building is never practiced out of France, and may be used only in isolated buildings like sea-coast forts, because it also dreads fire. Moreover, the engineer has to build *on time;* to build and to plan also and to calculate and decide, working always under a time penalty. Working so, planning so, he has only one way open to him so far as I can see—he has to build a structural shell or skeleton, mass or frame-work, and then to cover it up with terra cotta and with sheet metal, covering brickwork, without—with fine stucco, tiling and marble slabs within. There is a school of design in that, and one based upon the traditions, too; if we understood the traditions aright.

TO WHAT EXTENT AND IN WHAT DIRECTION IS IT DESIRABLE FOR A PROFESSOR OF ENGINEERING TO ACCEPT ENGINEERING EMPLOYMENT?

BY C. FRANK ALLEN,

Professor of Railroad Engineering, Massachusetts Institute of Technology, Boston, Mass.

It is common at the present time for professors of engineering to accept, to some extent, employment in the general practice of their profession as engineers, carrying on such work contemporaneously with their work of teaching. It is not uncommon for those in charge of engineering colleges to suggest, as an important inducement, that, in addition to his salary, the professor of engineering will have opportunity to engage in practice to an extent sufficient to materially increase his income, or even to double or more than double the salary offered. Cases are not altogether rare where the income from engineering practice does in fact exceed the salary received for teaching. Under such circumstances it will happen that in certain cases the demands of engineering practice may become sufficiently strong to interfere somewhat with the work of teaching, or may go so far as to dictate withdrawal from teaching altogether.

It is reasonably evident that the opportunity for abuse in the way of excess in the direction of engineering practice is sufficient to make it the part of wisdom to pause for a moment, long enough to care-

fully view the field, to consider to what extent, if at all, the teacher should engage in contemporaneous practice; and in this connection, to look into the matter further, to determine in what direction, aside from teaching, the engineering professor's activity may suitably be exercised.

There are many points of view from which the subject may be approached and examined. It is proper to consider the question with reference to the interests of the teacher himself, of his college, of the engineering and general public, and of the pupil. It may happen that practice, reasonable in extent, and in an appropriate direction, will be of definite advantage to all these classes. For instance, engineering practice adds to the income of the professor of engineering, who in many cases does not receive from his college a salary sufficient for his adequate support.

From a somewhat broader standpoint, a teacher can certainly do better work and will be a better man in many ways if he is assured of financial resources sufficient so that a consciousness of a lack of money for ordinary needs need not be a constant and unwelcome companion at his elbow. It is further true that contact with practical work is important in giving breadth of view to the teacher, in assuring a better conception of the interrelation between theory and practice, thus yielding a confidence, a certainty, a power, which his teaching may lack if the two elements of theory and practice are less firmly united. Not only does engineering practice yield income and power, but it may also readily yield reputation, which of itself is an element not to be despised.

For the engineering college, it certainly seems advantageous to secure for one of its chairs of engineering, some able man whom it would find it impossible to secure if his income must be limited to the salary which the college finds it practicable to pay. An opportunity for him to secure outside income seems almost the practical equivalent of an additional endowment. Furthermore, it is important to the college, just as it is to the teacher, that his contact with engineering work should prevent him from becoming narrow, and it also serves a good end if this contact increases his reputation and the reputation of the college. The advertising value, if you please to put it that way, of having its professors in contact with men of affairs and men of standing among engineers, is a legitimate consideration for the engineering college, whose success depends materially upon skilful business management, both in securing funds and attracting students; in either direction, both the reputation and the real ability of the teacher are important features.

From the standpoint of the student, whatever adds to the strength and the breadth of the teacher, whatever adds to the strength and reputation of the college, whatever serves to bring to the college pupils of character and ability, adds definitely to those advantages which any student seeks at an engineering college. Furthermore, whether or not it may seem undignified to suggest it, nevertheless it is the fact that there are certain points connected with a teacher's qualifications which appeal to a student in a degree which to us seems inordinate as regards their merit. Whether

we approve of it or not, the pupil does attach large, even fictitious value to the fact that his teacher has had, or does have, contact with actual engineering work. The statement of the teacher who has been in practice is readily accepted by the pupil when the same statement from the professor without practice is viewed with suspicion, sometimes ill disguised, sometimes not disguised at all. The skillful teacher who unites teaching ability with success in engineering practice, can, and in the writer's judgment should, utilize to the best advantage any such faith of his students, whether in his judgment on a fictitious basis or not, to stimulate them and to make his work count to the utmost. That a professor should directly ask for recognition from his pupils on this or any other ground is not wise nor should he pursue a course likely to injure other teachers, but it is not injudicious to make reference here and there to cases occurring in practice, even though unimportant, if in fact the result is to stimulate the students' interest and increase their respect for their teacher's instruction. In many ways the influence of actual practice, present or past, on the part of the teacher, will work definitely to the good of the pupils who will in fact profit more from the instruction given if their attitude towards it contains the elements of confidence and respect.

To the engineering and the general public there results some advantage in the fact that the engineer professor should and constantly must approach many engineering problems from a standpoint differing in an appreciable degree from that which the average practitioner would occupy. By this is meant in gen-

eral a standpoint not antagonistic, but rather in extension of, or in variation from that of the practitioner. Even though by chance the view should in some case have elements of narrowness, yet if it be pertinent and additional, it may have important value in the final determination of the course of action to be pursued in the settlement of some engineering problem. That this will result in benefit to the public and to the engineering fraternity is apparent. Cases are not altogether rare, however, where most satisfactory results have attended the employment of engineering professors whose actual experience has been supplementary to, and altogether the outcome of their work as teachers, or even when they have no direct engineering experience, and when their qualifications for their work have been directly those of careful students, whose work of study has been made more perfect by virtue of their work of teaching.

To the writer, who has been both practitioner and teacher, it seems clear and beyond the realm of controversy that there is great value to the professor, as a teacher, in definite experience in engineering practice, whether this be past or contemporaneous, and there is also value in contemporaneous practice, whether this follow past practice or not.

It is then incumbent on us to consider more directly to what extent and in what direction any contemporaneous practice is desirable ; to determine, if we can, what limitations, if any, should be placed upon such practice. To reach correct conclusions it seems proper to declare the fundamental proposition which it is hoped will not be successfully controverted, that the

teacher occupies the position of a trustee, and that the beneficiary of the trust which he assumes is the pupil. If this be the proper point of view, it is not sufficient that for the benefit of the teacher he should occupy a position such that he shall secure a resultant maximum in combining the income received, the honorable position secured, and the social and educational advantages yielded to himself and family. It is not enough that by virtue of such resulting maximum, the engineering college shall present in the list of its faculty an unparalleled array of names of men eminent in the various branches of engineering.

While the general public may contribute to the support of the State University or other college, while individuals contribute liberally in the way of modest philanthropy (although in some cases personal distinction seems to be the inducement) it is not enough that the general and the engineering public be largely benefited when the engineering professor engages in practice; the crucial test is, it must be, what is the effect on the welfare of the pupil when the professor accepts engineering employment? To approach the matter fairly, it is proper to assume that the teaching demands upon the professor must not be so severe as to compel effort to the point of substantial exhaustion. This must be conceded whether we approach the proposition from the standpoint of teacher, college, pupil or public. For the best results, this point of exhaustion must not be closely approached. There must be opportunity for relief from the routine, however interesting and enjoyable the work may be. The best way to prevent bad ruts even in a road is to avoid wheeling

continuously in a single line and so not allow the rut to become even started. A narrow road ruts more quickly than a wider one.

When the immediate demands of teaching are satisfied, then there remains time available, and which should ordinarily be used for the broadening and general improvement of the engineer-teacher. But what shall be the direction taken? The answer in any specific case depends partly upon conditions and opportunities and partly upon temperament. Let us suppose a case. A young professor in the line of structural work, substantially if not entirely without direct practical experience, but who has superior theoretical preparation, is offered a position where it is his main duty to pass upon the safety of hundreds of railroad bridges, and at an adequate salary. What shall he do? The position yields many advantages to him, among which the salary is perhaps not, on the whole, the most important. His acceptance and incumbency of office is regarded by the president as advantageous to the engineering college he represents. In a lifetime he cannot expect an equally favorable opportunity to acquire an intimate acquaintance with the practice, past and present, of various bridge engineers and various bridge companies, his duties extending naturally to the study of details. Of necessity this experience must be of great benefit to his pupils, for it is altogether in the line of his teaching work. He unites eminent qualifications with a temperament very fortunate under the special circumstances that exist, so that he may properly assume that some duty to the public rests upon him. It means, however, a sacrifice

in ease, it means for a time work into the morning hours, it means the acceptance of large responsibility. Yet his acceptance seems, as it certainly must be, definitely to the advantage of all four classes referred to in this paper. The duty to assume the work is well-nigh imperative. This case is clear, and is not altogether an imaginary one.

Take another case not unlikely to happen. An engineering college desires as its professor in a certain branch of engineering, a man of large practical experience, a graduate of an engineering college and thus already well grounded in theory; a man desirable apparently from all standpoints. The salary available, although not small compared with salaries paid elsewhere, is insufficient to secure him. The opportunity for contemporaneous engineering practice is suggested by the college authorities and meets the approbation of the engineer who accepts the position of professor of engineering. On the whole, it seems to prove a good move for him. His position as professor in charge of a department of engineering is really the cause of an increase in the demand for his services. He accepts many opportunities and serves often as consulting and perhaps even as constructing engineer. The income he receives, while very large, is perhaps to him less a consideration than the distinction and advancement as an engineer which are involved, and which work not only to his advantage, but call favorable attention to his college as well. To be sure, there must be prolonged absences. New practical problems come up in lines foreign to his teaching and these absorb much of his attention, so that his best efforts

are expended in practice and not in teaching. In fact, perhaps a minor consideration, the engineering side is to him so important that he has no time to attend the meetings of this Society. To him it seems more important to keep in touch with the large engineering societies. Is it too much for us to suggest that he has time to expend to make himself a better engineer but not to make himself a better teacher?

Is this picture overdrawn? Perhaps so. And yet a well-known engineer, not in the writer's city, a man of broad views, whose judgment the writer has always highly respected, states that his son attends an engineering college where he believes the professor in charge of a department does in fact seriously neglect his work of teaching in consequence of exceptional demands for his services. If this is true, how is this professor administering his trust? How is the college, a joint trustee, administering its trust with reference to the beneficiary, the pupil? Is it not true that the case just referred to has a parallel in more than one case?

It must be conceded that if engineering employment is accepted, in its extent it must not seriously interfere with the teacher's duty to his pupil. The Cunard Steamship Company's line is often regarded as a model for the discipline maintained on its ships. It has been stated to the writer that one of the captains on its line applied, practically on the day of sailing, for a leave of absence to be spent at the bedside of his dying wife. The discipline of the service seemed to require this answer, "Several hundred people have engaged passage on your ship; many have done so on the basis that you will sail the ship. Under the circumstances

we regret to require that if you are able to reach the ship you must sail." The captain sailed on that voyage. The student who is enrolled at a certain college has done so because Professor B. teaches the subject essential to him for his life work. He is entitled to such instruction. An unwarranted failure to furnish it is a breach of trust and a wilful failure is a fraud. Must we add to the corporation director who does not direct, and to the sea-captain who does not sail, another delinquent, the teacher who does not teach?

What direction shall the professor of engineering pursue in utilizing the time available after satisfying the direct teaching requirements? To repeat, this is partly a matter of conditions and opportunity, partly of temperament. The man well adapted to it will engage in engineering practice if opportunity offers. Without the opportunity, he will seek another useful outlet. Another, when tastes and opportunity unite, will profitably engage in research. In the case of one of our members, could general practice have yielded better results in his power over his students than must have been secured by a very valuable discovery in electricity, perhaps the most important of the year, a discovery due to persistent research? Isn't it true that the writer of one of the best books upon some engineering subject does secure a hold upon his pupils which indifferent practice might not have secured? Doesn't the member of a town or city school committee add to his ability and skill as a teacher by virtue of such work? Doesn't the professor who carries his share of the burden of citizenship set a worthy example

to his pupils? Isn't it fair to claim that one of our best-known members, as Mayor of his city, must, by virtue of his position as a man of affairs, appeal more strongly to his students and secure from them a larger share of interest and respect?

Travel and inspection of engineering works under construction or in operation will often yield superior experience, especially to an engineer who has previously had his share of practice, as will attendance and activity in societies of engineering. Time devoted to general culture is by no means lost in the influence it exerts upon a teacher's success. On the contrary, repeated performance of certain lines of engineering work quite foreign to the subjects under the professor's charge will add little to his teaching efficiency and are probably not valuable except as a source of income. It is needless to suggest that the professor's services should not be secured for fees smaller than those recognized as proper by the engineering profession. The engineering professor should be the last to violate proprieties in this direction.

It is not intended in this paper to exhaust the changes and varieties of occupation allowable for the professor of engineering, nor to prescribe those things which are unsuitable. Enough has been said to indicate the lines of action which should guide him. The application of the principles involved should rest with each individual. If the teacher has a proper conception of the standard by which his action should be controlled, together with a sincere purpose to perform his duty, such errors of honest judgment as may from time to time occur will seldom lead to seriously unfortunate

results. These principles may somewhat briefly be summed up. It is just and proper for the teacher to require that adequate time and opportunity be granted him by his college so that he may broaden and develop into something better than a mere teaching machine, and this for the benefit of all concerned. It is, however, wise and reasonable that the college should in turn exact from the teacher that the time and opportunity shall not go to waste, but shall be improved in proper extent and direction for the benefit at least of both college and pupil, and perhaps also of the community. But it is strictly imperative, both on the college and on the teacher, that the latter should clearly recognize his duty to the student, who is entitled to receive in amount, quality and distribution, and from the proper person, that instruction which he has naturally been induced to expect when he determined the college which he should attend.

It is not essential that there should be a technical and narrow compliance with the principles enunciated. An exercise may sometimes be postponed or technically omitted. Something of give and take between teacher and pupil may frequently be directly beneficial. A favor asked and granted between teacher and pupil in either direction serves a good purpose in tending to emphasize the relation between man and man rather than between teacher and pupil, and the hour apparently wasted may thus sometimes serve as the most profitable hour of the term.

Neither can it be maintained rigidly that no circumstances can occur which will justify some actual immediate neglect of the students' interests. In this busy

world, complications arise which sometimes clearly dictate the neglect of duty in certain directions. It is confidently urged, however, that any neglect of the pupils' interests, however necessary seemingly, shall not be incurred carelessly or willingly, but in any case with a clear appreciation of the duty and with strong mental protest against its infringement. While it may seem necessary at times to run apparently or temporarily contrary to the pupils' interests, these should never be lost sight of, and should be conscientiously protected. It is not improper to repeat that the teacher is a trustee, and the beneficiary of the trust is the pupil. The college itself is equally a trustee, and college and teacher can both properly consider it a part of their duty to supplement each other and to each correct any errors of the other.

TO WHAT EXTENT SHOULD ENGINEERING TEACHERS ENGAGE IN OUTSIDE WORK.

BY WILLIAM KENT,

Consulting Engineer, and Associate Editor of *Engineering News*, New York City.

This paper is presented not because I have any personal interest in the question which forms its title, but simply because it has been requested by the Committee on Programme in the hope that it will lead to a discussion. The Committee has asked me to write it probably because I am not an engineering teacher, but only a layman, a consulting engineer, and am therefore supposed to be able to consider the question from another standpoint than that of an engineering teacher.

The question is an old one. I have heard it discussed in private many times, but have never, to my recollection, seen a discussion of it in print. It has been smouldering a long time; it is well that it should be ventilated. The question has its origin in a number of complaints. Let us give a hearing to the complainants.

The first is a board of trustees of a college. We hear, say they, that Professor Blank is making a great deal of money in fees for outside work. Ought we not to cut down his salary? This particular complaint was made several years ago concerning the head of a department of one of our leading engineering colleges. I give the story as I heard it from one of the professor's many friends. He was called upon to an-

swer the complaint, and given a day to prepare his answer. Like a sensible man he consulted his wife. She said, "Figure up exactly what you have made from outside work during the last year, and hand the record to the Trustees, and let them see how it compares with what they have been paying you." He did so, and the Trustees saw from the record that he had made $30,000 a year outside, while his salary as professor was only $7,500. "Well," said one of the Trustees, "we are getting for $7,500 a year half of this man's time, while outsiders are willing to pay him $30,000 for the other half. I think we are getting him mighty cheap." So his salary was not cut down; he still holds his position, and, I am told, at a larger salary.

The second complainant is a consulting engineer, who is not a teacher. He has an office and sometimes finds it rather hard to pay office rent. "The trouble is," he says, "these college professors are cutting into our practice. They have their salaries to live on, and they can afford to name lower prices than we can. They also have the prestige of the college name, which is a good advertisement for them." The reply to this man is, "Didn't you know that before you hung out your shingle? That is part of the penalty you pay for being a consulting engineer. If you don't like it, why don't you become a college professor yourself. If the professor is making more money than you are, it is only an illustration of the general rule, 'To him that hath shall be given,' or as David Harum puts it 'Them that has, gets.'"

I have tried to investigate the charge that the engi-

neering teachers are in the habit of cutting prices when they do outside professional work, but have not been able to find any basis for it. I think their charges are usually quite as high as those of the outside consulting engineer. They have generally a sufficient idea of professional and professorial dignity, which tends to make charges high, and the fact that they have a salary to fall back upon makes them less anxious to get jobs than the consulting engineer who has no salary but who has to pay office rent.

The third complainant is the engineering student. "Professor Doe" is absent from his classes about half the time. He gets the biggest salary in the place and he doesn't give a fair equivalent for it. "What is the character of his instruction?" we ask. "Oh, that is A No. 1; I wouldn't give one of him for half a dozen of the others. We learn more from him than from all the rest put together. I am only kicking because he doesn't give us enough of his time." "Well, there is Professor Roe," we say, "who gives all his time to the college. How does he suit you?" "Oh, he's an old fossil. He's twenty years behind the age. He ought to be retired."

The last complainant is an old professor, the head of a department. He was famous twenty years ago, and he did outside work then and obtained the largest fees ever given to a member of the engineering profession. He has retired from outside work now, being old and rich, and is a good professor yet, but he seems to have changed his mind about the desirability of a college professor doing outside work. He even objects to their writing books during vacation to eke out their

small salaries. He says the professor's whole duty is to his students. When he is not actually engaged with his classes he should be preparing for them and his vacation should be devoted to obtaining mental and physical rest, so as to give him strength to perform his duties during the terms.

So much for the complainants. Let us now hear the defence. Since being requested to write this paper I have interviewed several professors about the subject, and have tried to find out how general is the practice of a teacher's doing outside work, and why they do it.

One of the youngest teachers says, "I do all I can get. Wish I could get more. If I didn't do any I would starve." Another young professor says, "I do a little. I am looking for a job now. Can't you get me something to do during the summer?" Another says "Why we all do it. If I couldn't do it I wouldn't be a professor."

The head of an engineering department of one of our largest universities tells me he has no time for outside work; his college duties take all his time; but in his younger days he did a great deal of it, so much that his outside fees amounted to more than his salary, and that was not a small one. Several professors have given a direct answer to the question at the head of this paper, "To what extent should an engineering teacher engage in outside work?" as follows: "He should do all that he can get, provided that it does not interfere with his duties to his classes." This seems to be the general opinion among engineering teachers.

Two reasons are given why an engineering teacher should do outside work. The first is a financial one. It is that the salaries paid to engineering teachers are not sufficient to enable them to live in the comfortable style in which a professor ought to live, and they are not as much as an engineer of ability would earn in other branches of the profession. The second reason is that if an engineering teacher does not do some outside work he will not be a good teacher; we will consider this reason in detail later.

It is a matter of common observation that the great teachers of engineering are those who either are doing, or have done, in years gone by, a great deal of outside work. Many engineering teachers have acquired world-wide fame not through their teaching but through their work outside of teaching, whether as authors, as lecturers, as consulting engineers, or as experts in scientific research. It will almost always be found that these men are not only great engineers but also great teachers. Their fame enhances that of the university in which they teach. Their personal qualities are such that they obtain the admiration and love of their students, and their friendship is cherished by their students as one of their choicest possessions.

The same is true in other professions than engineering. The great teachers in medical colleges are the great surgeons and physicians; in the law schools they are the great lawyers.

The proper standpoint from which to consider this question is that of the student. For his good, and for the good of the community which he is to serve in after life, the university exists. He spends there four

of the most important years of his life. During this time he is to acquire not only the strictly technical knowledge of his profession, but also a large part of his culture as a man. How otherwise can he obtain this knowledge and this culture unless he is provided with the best possible teachers. Millions are being furnished by our rich men for the fine buildings and equipment of our colleges, and the money is well invested, but still our colleges remain poor, so that it is impossible to pay the salaries that are desirable, and they always will be poor, because the supply of students demanding an education increase as fast as buildings can be erected to accommodate them.

The engineering student needs, more than buildings and equipment, the best possible teachers. Not Professor Dryasdusts, who will through so many hours a week cram them with text-book knowledge, but broad-minded, all-around men, acquainted with the world, experienced in actual engineering work, who know how to select from the vast field of theory and practice those things which are most useful for the student to know, and who will not waste his time on unessentials.

The ideal engineering teacher is a man of broad culture and genial disposition, thoroughly versed in fundamental theory, well acquainted with the latest practice, and possessed of the teaching instinct and enthusiasm. The teacher who devotes all his time during the college terms to teaching, and his vacations to rest and recreation, may have all the qualifications except one—that of acquaintance with recent practice. This he cannot get except by engaging in outside prac-

tice. Engineering shops, power plants and field work are always in advance of the schools. New problems are constantly arising in practice which it takes years to get into the text-books. It is necessary then, in order that an engineering teacher be a good teacher, that he should engage in some outside work.

To what extent should he engage in it? To the greatest extent possible, provided that he does not neglect his classes. His duty to his students should be the first consideration. During how many of his class-hours he may be permitted to be absent from his classes may well be a matter of contract between him and the trustees of his college, a proper substitute being provided, at his expense, if necessary, when his absence is of any long duration.

It is the prevailing custom for engineering teachers to engage in outside work. It has always been the custom, and experience shows that such work improves the quality of the teaching. The custom, therefore, is a good one, and it should be continued within the limitations above described.

Discussion.

Professor Nagle.—If many of our college boards which employ engineering teachers at miserable salaries could listen to Mr. Kent's exposition on why they should do outside work and the value of their services, the salaries of engineering teachers would not be so low. The speaker endorses the paper throughout.

Professor J. B. Johnson.—The speaker approves both papers most heartily, and is rather sorry that they

were not presented before, because this is a subject in which papers coming from this Society can be made very useful at some very critical times. For instance, in the University of Wisconsin it is against the rules for the professors to leave the city without permission from the executive board. Well, the President and the Dean have a little secret society of their own and they arrange that matter between them and the executive committee doesn't want to be told anything about it. They say it is a very good rule if one doesn't do too much with it. But the speaker does not know how to get a five-thousand-dollar man for twenty-five hundred dollars unless he gives somebody else the opportunity of paying him the other twenty-five hundred, and he wants as many five-thousand-dollar men as he can get.

MR. W. A. HAVEN, the President of the Society of Engineers of Western New York, being present, was invited to address the Society. He spoke upon the necessity of training students to be accurate, even where rough methods and instruments were of necessity used, and illustrated his point by incidents drawn from his own professional experience.

PROFESSOR ALLEN.—From the speaker's standpoint, even if the professor and the engineering college have a contract that is satisfactory between themselves, it does not follow that the matter is settled right. The pupil certainly is entitled to consideration in the matter, and there is at least a reasonably fair chance that a professor who earns thirty thousand dollars outside his college is not giving a proper amount of time to the college work, and although that may be very satis-

factory to the college authorities, it is doubtful whether it is right; it is doubtful if the student is getting all that he is properly entitled to.

MR. KENT.—The speaker does not want to give the man's name, but he has heard recently from some of this man's pupils that he is the best professor they ever knew; that they wouldn't give him for a dozen other professors, and it is the opinion that every student who has ever graduated under him says the same thing, and that they are glad to be under him.

RESEARCH AND PUBLICATION AMONG ENGINEERING TEACHERS.

BY WILLIAM S. ALDRICH,

Director, Clarkson School of Technology, Potsdam, N. Y.

"On the maintenance of universities modern civilization depends. It is not only their noble function to discover and make known the truth, but every field of inquiry is open to them. The universities are the discoverers and explorers of new domains. They are the modern judges of the world. Neither the State nor the Church can reverse their decisions."—President Daniel C. Gilman on "The Function of the University."

The very nature of the field in which engineering teachers work and the character of the instruction they are expected to give require a peculiar combination. It is apparently more and more difficult each year to find men fulfilling all of the exacting requirements of such responsible positions. Men of so-called academic habits of thought and work are entirely out of place. They are neither in touch with practical work nor imbued with the professional spirit. They can but approach the subject from the schoolmaster's point of view. Too frequently it would be considered a violation of their sacred trust, at variance with all precedent, to enter into and dwell upon the practical details of their instruction. The practical engineer with an aptitude for teaching will rarely forsake the former field for the latter. When he does, he is

quite likely to teach that which he has found or developed in his own practice rather than that which is of general application and utility. Between these extremes are all sorts and conditions of men.

The engineering teacher should be more and do more than the functions of his office might seem to require. It was clearly not to drive this home that the secretary requested the three papers bearing upon the proper professional and scientific work of the members of this Society. Rather, let us think it was to make clear the distinctions in such duties where there are real differences in aptitude, habits and field of work. It goes without saying that the members recognize and consider outside work in the light of a duty, expressed or implied, which is owing to the institution, to the students, to the profession and to themselves. Otherwise, it might seem that the duties of the members required defining. Perhaps, also, rapidly shifting external conditions are beginning to make necessary some changes in methods, spirit and work within academic halls, and this not only during vacation periods but as the natural growth of a mind fitted to its task, to whom:

> "Rest is not quitting this busy career,
> Rest is the fitting of self to its sphere."

This is an age of industry in the broadest sense of the word. Whether in the fine and the liberal arts, or in agriculture and the mechanic arts, we are witnessing the development of diversified activities that cannot but increase and inure still further to the establishment of our national welfare. The mechanic arts and industries will continue to grow in import-

ance and power whatever attitude engineering teachers may take regarding their promotion. But it is well recognized in those countries where there is the closest touch between technical education and practice that it is no longer the custom for engineering works to put up the sign: "No technical graduates need apply."

The three R's of engineering may be classified as:

(1) To draw and design.

(2) To experiment and investigate.

(3) To construct and execute.

It is usually in one or the other of these fields that the engineering teacher is called upon to give instruction, directly or indirectly. Therefore, along similar lines, we may expect to find him at work, in so-called "outside work," during the leisure time of his life. The few teachers who have become great designers or inventors have usually quit teaching on their way to prosperity. It goes without saying that no teacher becomes a great constructor or chief executive of large interests and remains at teaching, at least it is not in the nature of things nor of the man.

It is the purpose of this paper, therefore, to consider the relation of engineering teachers to the second line of work above noted, that of research. It is especially the field in which they are supposed to engage, with least friction and probability of adverse criticism from their fellow-teachers, the authorities and the engineering public. It is, moreover, that in which they have obtained the greatest eminence and rendered the most lasting service to the profession while remaining in their respective chairs.

The instruction given by engineering teachers must

be based upon their own researches or those of others. Life is very short to establish much of a precedent and recourse must be had to the results obtained by earlier workers. It is sometimes difficult to steer a clear course between too ready an acceptance of the past experience of others, on the one hand, and too little respect for it, on the other. Instruction to command respect must be founded upon the truth. However much or little may be known in any branch, that which is given to the student must be correct. It is in the laboratory, therefore, where almost all that has been taught or may be taught in engineering science may be thoroughly tested. In consequence, it is especially important that the engineering teacher should have that scientific bent of mind, by nature or by training, which gives itself willingly to the most careful scrutiny of every principle, subjecting the same to rigid tests where necessary or helpful to the student.

In this question of research and publication teachers are most likely to be divided just where they should be most united. There should be coöperation without duplication. For instance, the American Institute of Electrical Engineers* some time ago sent to institutions giving courses in electrical engineering, a syllabus of researches, which it was suggested might be undertaken in their electrical laboratories according to their respective facilities. Special request was made that the Institute might be notified of the prospective lines of such investigation on the part of the different institutions that researches might not be duplicated. This action has stimulated to much ex-

* Report of Committee on Coöperative Research, Transactions American Institute Electrical Engineers, vol. xvi., p. 16, May 186, 1899.

cellent work. It would prove equally helpful if the other national engineering societies should pursue a similar course.

Whatever attitude teachers may take regarding such researches, it must be recognized that similar work is going on all the time in the larger engineering establishments, at the head and front of which are some of the best trained technical graduates. Manufacturers are not in business for the promotion of research and the advancement of science. Little if anything is published respecting the results of their investigations. To this extent the world is the loser, however much the manufacturer may gain. There is therefore entirely lacking that openness, frankness and freedom in the dissemination and discussion of the results of research so characteristic of true scientific workers and especially marked in the publications of the Reichsanstalt, at Charlottenburg, Germany.

There is only one country in which scientific and engineering research may be said to lead or at least to keep pace with industrial developments. Yet in our own country it is similarly aided by public grants and private benefactions without corresponding results accruing to the benefit of national industries. There is lacking among us somewhat of that indefinable scientific spirit. Few researches have been undertaken which do not savor of a proprietary interest, or have some immediate or special value to corporate investments, to that extent relieving such concerns of the necessity of carrying on their own researches. Assistance is, of course, rendered some industry, infant or otherwise. But it is a serious question whether such

results should not be obtained by manufacturers, in their own laboratories, under conditions best suited to the development of their specialties. The well-springs of scientific truth are not so far exhausted that there is nothing left for the engineering teacher, in the way of research, but to work at it secondhanded, perhaps going no further than to corroborate the earlier work undertaken by manufacturers.

Commendable work by the young has been the exception. Ruskin doubted very much if a young man could produce anything worthy of the world's recognition till he had reached a given age, a kind of intellectual majority. The latest requirements of the national engineering societies fix a minimum age limit for the privileges of full membership as an indication of a kind of professional maturity. However, in the field of science as well as of art and of letters, many an illustrious exception may be found where really valuable work has been done long before the conventional age has been reached. The late Henry A. Rowland, while a student at the Rensselaer Polytechnic Institute began a series of classic experiments upon magnetic permeability. Completing the work soon after reaching his legal majority it was laid before the American scientific press of that time only to be refused. He very soon after received that recognition from Clerk Maxwell and early publication in the *Philosophical Magazine* which won him the professorship of physics in the Johns Hopkins University.

It is late in life, on the other hand, when many men find themselves or their work. An awakening to their endowments and possibilities seems to come only after

many a year of wandering, it may be years after the age at which the conventional type of man is supposed to mature. None the less valuable scientific work has been done by men of this class when compared with the former.

To publish nothing till one has done something original would result in a speedy and delightful reduction of a mass of printed matter in all technical lines. Engineering literature is becoming more bulky and less nutritious each month. In recognition of this deplorable condition something ought to be done by engineering teachers, perhaps more by example than by precept, to remedy the evil tendency of a certain class of engineers to rush into print.

It is scarcely probable that engineering teachers will publish too much. Their tendency is all the other way. The very nature of their vocation and the trend of their inclinations lead them to refrain from publication. They hesitate to enter a field already crowded by men of a different type and sometimes of quite a different aim in publication work. This is to take merely a negative stand, as influential as most negative attitudes usually are found to be. It may even tend to invite publication from many engineers much less prepared, from penny-a-liners and hack writers, in order to supply a real want and meet a real demand for information of some kind upon engineering subjects.

It is incumbent upon all engineering teachers to take a definite and intelligent stand in this matter and thereby exert a real positive influence. The question of the kind of publication scarcely requires considera-

tion, whether it be text-book or monograph, contribution to current technical literature or to the transactions of engineering societies. It may be left to adjust itself in each case.

It cannot detract from the value of the teacher to engage in technical and scientific publication, whether to promote engineering education or to reach the industrial problems of the day. In all of the possible varieties of such work it cannot but serve to stimulate to greater activity and productiveness on the part of his associates, assistants and perchance students. A healthful stimulus is always needed to enlist the services of able undergraduate or postgraduate students in the work of carrying forward the college technical journal. Publication will tend to produce greater harmony in the work of engineering education and research, resulting in mutual interchange of information, materially aiding its promotion and elevating the aim, tone and character of the work.

Judicious publication by engineering teachers will arouse a larger interest and a broader view of engineering as a profession and in the education required for this calling. Where there is the least to be gained by husbanding information it is lamentable to find how extensive is the confirmed reticence among able engineering teachers. Publication will advance engineering education along such lines as to command the respect of fellow-teachers in other educational lines. It will enhance the value of the opinions of teachers upon vital and pressing questions of professional work. It will remove the reproach that as a body they are not as much interested in the general progress of the

profession as their commanding position in the educational world would demand.

Researches of real intrinsic value are now being carried on in many of the technical schools of the country. The results should be given to the engineering public. It has somewhat of a right to expect that information applicable to lines of industrial work may be freely published and used. Friendly criticism will be invited from the fields of practice, criticism of which the teacher stands most in need, owing to his hourly contact with young and immature minds. Educators and manufacturers will be brought into closer relations, never likely to be too close for the good of either, not to speak of the resulting benefit to the students. The very direct bearing of engineering education and research upon the development of industry will be clearly shown. Material aid will be given to that expansion of trade and commerce, mines and manufactures which is the modern index of a nation's prosperity and which is now acknowledged to be greatly accelerated by scientific research and the publication of results.

Regarding text-books, it may be said that it is not given to all teachers to be text-book writers. There are those, however, to whom such endowments and necessary opportunities are given who certainly owe a large debt to the cause of engineering education. It is a pleasure to note in how many instances this obligation has been most satisfactorily discharged. American engineering text-books have a characteristic freshness, vitality and nearness of touch to natural conditions, the result of their authors having had to blaze

many new paths in such an environment. The authors have had that appreciative touch with theory and practice most suited to a training for engineering practice under American conditions. Perhaps we should not have cared to have had this otherwise, during the last century. As it is now, we must not be blind to the fact that these conditions incident to the early development of our country and its industries are rapidly passing away. The American engineer cannot, if he would, stay at home while the products of his country are entering every open market of the world.

International possibilities and competition in engineering as in trade open the larger questions at the beginning of the century. The American engineer would scarcely be loyal to his racial instincts if he remained by the hearthstone and fireside under these twentieth-century conditions. A proper recognition of them is destined to influence materially the character and scope of engineering education in these early years. Foundations must now be laid broad and deep. Principles are to be developed of general utility rather than as formerly, best suited to American conditions. Examples, illustrations and applications are to be noted wherever found most suitable, whether at home or abroad.

An enlarged horizon, a broad outlook, is what American engineering education seems to stand most in need of at the present moment. This must come from an examination of foreign engineering works frequently executed under totally different conditions from those under which we are accustomed to work

at home. This is not to open the question of generalization *vs.* specialization. In his own specialty, however, let the young engineer take an international point of view, let teachers make their lectures and work doubly interesting, inspiring and valuable to their students in preparation for that profession whose field is the world.

An experienced and successful engineer has put the matter in the following form:

"1. Teachers should not be overtaxed with routine work as they are in some institutions. No stimulus can be expected or prominent work developed where exacting routine requirements are in excess of man's capacity.

"2. Time should be allowed for the teachers to think for themselves and on matters outside of the daily lessons. There should be much more freedom of action than is common in American institutions. Teachers should be able to keep up with the progress of their profession, at least in their special lines.

"3. Time and facilities should be provided for athletic and recreative sports, enabling teachers to relax somewhat from the 'model and example' which they are supposed to be, and to maintain themselves in as buoyant health as the student body.

"4. Attendance of teachers upon conventions—educational, scientific and technical, should be more encouraged. It would stimulate intercollegiate competition and foster better intercollegiate relations than now exist. It would ensure that personal contact of the workers from the various institutions so essential to their mutual inspiration, encouragement and success.

"5. Papers should be prepared for such meetings, upon special topics relating to their work or researches. This should be encouraged in spite of the frequent lack of special facilities for extensive researches in their particular fields. In other cases, notably in institutions doing a large share of postgraduate work, excellent equipment is provided for special researches. It is naturally expected that their corps will utilize to the utmost these facilities, discovering new facts, presenting the results in papers and discussing them fully and freely with other workers in the same fields.

"6. Teachers should break through the ice of indifference and silence by the merit of their papers. The rest will follow. Students will think more highly of their instructors. In the profession they will have some standing in the community of engineers. The public in time will recognize the intrinsic value of whatever may be published. It will bring the institution to the attention of the people in a desirable way.

"7. Interest should be aroused and maintained in the advancement of science as well for its own sake as for the aid it may render in the development of national prosperity. Why point always to Germany as an example of thoroughness, or to England for the eminence of her physicists, or to France for the renown of her chemists? Raise a national ambition, develop united scientific spirit, harmonize ideals and seek their attainment. We have here the forces and resources, and the material out of which earnest and conscientious workers are made.

"That these are the essential requirements can be

proved by the inquiry, What makes an instructor dry and uninteresting? It is the teacher who has his subject laid out for a year and has all of his lessons printed and works like a shoemaker always over the same last, not aspiring to think in new channels, nor progressing with the times, and on whom neither time nor surroundings can produce any impression. Such a teacher is so much older than his students that it would be beneath his dignity to depart from the methods of the last century. The success of a teacher depends upon his being ever young even in his old age, to keep up with the times and to aspire to loftier ideals as he advances each year. Only with such aims can he hope to inspire his students and produce results that we have known in the lives of such men as Helmholtz, Weber, Faraday, Maxwell and Rowland. Professors favoring a retired life will see those go ahead of them who have the scientific and cosmopolitan spirit of the age."

At the former Buffalo meeting of the Society in 1896, the question of engineering research and its federal endowment was variously discussed.* Since that time, two federal institutions have been established by acts of Congress passed at the last session, the one a National Standardizing Bureau of Weights and Measures, the other an Institution for Scientific Research. Both of these are to be located in the city of Washington, D. C. Already movements are on foot to affiliate with such lines of work the National

* "The Conservation of Government Energy through Education and Research," by C. W. Hall, *Proceedings*, vol. iv., p. 174.

"The Hale Engineering Experiment Station Bill," by Wm. S. Aldrich, *Proceedings*, vol. iv., p. 187.

Educational Association, the Association of American Universities and the Association of Agricultural Colleges and Experiment Stations. It is none too soon to consider what relation the Society for the Promotion of Engineering Education is to bear to these two national institutions which are destined to exercise upon scientific research and the engineering industries of this country a profound influence akin, let us hope, to that of the German Reichsanstalt.

REPORT OF THE STANDING COMMITTEE ON ENTRANCE REQUIREMENTS.

In accordance with the plans presented at the New York meeting of the Society, the Committee has occupied itself during the past year with an attempt to secure assent on the part of engineering colleges to the principle of the adoption of standard formulations of entrance requirements by this Society and in the second place, criticism on the part of the engineering colleges of formulations for the following subjects:

Algebra (elementary),	English,
Algebra (advanced),	French (elementary),
Plane Geometry,	French (intermediate),
Solid Geometry,	German (elementary),
Physics,	German (intermediate),
Chemistry,	History,

Free-hand Drawing.

The accompanying circular and pamphlet were accordingly sent to all members of the Society early in the spring.

The formulations sent out were based on the recommendations of the Committees of the National Educational Association; on the existing definitions in certain colleges; on the recommendation of the Committee of Twelve of the Modern Language Association; on the recommendations of the Committee of Seven of the American Historical Association. In each case the person addressed was requested to answer the following questions:

1. Is this formulation in your judgment adequate

for the needs of students in engineering courses at your institution?

2. If it is inadequate, what changes should be made?

3. What is the probability of the acceptance of the above formulation by your institution?

4. Will your institution accept the certificates of another for an entrance examination based on this formulation?

5. Will your institution approve the acceptance of the above formulation as a basis for a course in a secondary school whose certificates are now accepted for admission?

Replies to these questions have been received from a number of colleges.

The committee is of opinion that the answers to Questions 3, 4 and 5 depend to so great an extent upon the answers to Questions 1 and 2 as to preclude a formal report at this time. With a view to making the most effective use of replies to Questions 1 and 2, the committee desires more time to consider each formulation and the criticisms affecting it.

[Signed] JOHN P. JACKSON, *Acting Chairman*,
MANSFIELD MERRIMAN,
F. W. MCNAIR,
F. O. MARVIN,
J. C. NAGLE.

July 1, 1901.

[Copy.]

Society for the Promotion of Engineering Education.

Committee on Entrance Requirements.

Dear Sir:—

The Society for the Promotion of Engineering Education appointed a special Committee on Entrance Requirements at the Brooklyn meeting of 1894. The Committee has since been made a Standing Committee and charged with the execution of certain functions, including

1. The collection and presentation of information in regard to changes of requirements;

2. Attempts to secure on the part of engineering colleges:

(*a*) The selection of entrance subjects from a certain list;*

(*b*) The acceptance of certain definitions of subjects on this list;

(*c*) The proper regulation of acceptance of certificates from secondary schools and from other colleges.

* The recommendations of the Committee on Entrance Requirements (see Vol. IV., Proceedings) were as follows: For the higher grade of engineering colleges the minimum requirements should include—Algebra, Advanced; Plane and Solid Geometry; Physics with Laboratory Work; Chemistry with Laboratory Work; New England Requirements in English; Two Years of Foreign Languages; American History and some additional History; Free hand Drawing.

For the second grade the minimum requirements should include: Algebra through Quadratics; Plane Geometry; Physics (this should, preferably, include laboratory work); One Year of Foreign Language; English along the line of New England Requirements but less in amount; American History; Free-hand Drawing.

Relying on the earnest coöperation of every member of the Society, the Committee respectfully requests that you give the accompanying blanks thorough consideration and reply not later than April 5th.

It will be recognized that the expressions of opinion desired by the Committee are those which have most weight in shaping the policy of the institution. It is accordingly requested that answers be based, if possible, on consideration by Faculty committees and that in case of the proposed formulations of entrance subjects, the coöperation of the respective departments be secured.

Yours very truly,

HARRY W. TYLER, *Chairman*,
J. P. JACKSON,
T. C. MENDENHALL,
MANSFIELD MERRIMAN,
C. D. MARX,
F. W. MCNAIR,
F. O. MARVIN,
J. C. NAGLE,
R. B. OWENS,
W. D. PENCE,
JOHN J. FLATHER, *Secretary*.

[Copy.]

COMMITTEE ON ENTRANCE REQUIREMENTS.

PROPOSED
DEFINITION OF REQUIREMENTS.

Society for the Promotion of Engineering Education.

March 1, 1901.

DEFINITION OF REQUIREMENTS.

MATHEMATICS.

The subjects of examination, and the definitions of Elementary Algebra and Advanced Algebra, are those recommended by the committee of the National Educational Association.

The definitions of Plane Geometry and Solid Geometry have been determined, in accordance with the recommendations of the Committee of the National Educational Association, chiefly by the present requirements of several representative colleges.

FORMULATION I.

(*a*) **Elementary Algebra.**

I. To QUADRATICS, including the four fundamental operations for rational algebraic expressions, factoring, highest common divisor, least common multiple, complex fractions, the solution of equations of the first degree containing one or more unknown quantities, radicals and fractional exponents.

II. QUADRATICS AND BEYOND, including quadratic equations in one and two unknown quantities, ratio and proportion, the progressions, the elementary treatment of permutations and combinations, the binomial theorem for positive integral exponents and the use of logarithms.

FORMULATION II.

(*b*) **Advanecd Algebra** including the elementary treatment of infinite series, undetermined coefficients, the binomial theorem for fractional and negative exponents, the theory of logarithms, determinants, and the elements of the theory of equations.

FORMULATION III.

(*c*) **Plane Geometry**, including the solution of simple original exercises and numerical problems.

FORMULATION IV.

(*d*) **Solid Geometry**, including properties of straight lines and planes, of diedral and polyhedral angles, of projections, of polyhedrons, including prisms, pyramids and the regular solids, of cylinders, cones and spheres, of spherical triangles and the measurement of surfaces and solids.

In solid geometry, plane trigonometry and advanced algebra the schools should insist upon the same amount of work and aim at the same standard of scholarship as the best American colleges require in their courses in these subjects.

PHYSICS.

The requirement in Physics is based on the report of the Committee on Physics of the Science Department of the National Education Association.

FORMULATION V.

It is recommended that the candidate's preparation in physics should include:

(*a*) Individual laboratory work comprising at least thirty-five exercises selected from a list of sixty or more, not very different from the list given below.

(*b*) Instruction by lecture-table demonstrations to be used mainly as a basis for questioning upon the general principles involved in the pupil's laboratory investigations.

c. The study of at least one standard text-book, supplemented by the use of many and varied numerical problems, "to the end that the pupil may gain a comprehensive and connected view of the most important facts and laws in elementary physics."

FIRST PART.

Mechanics and Hydrostatics.

1. Weight of unit volume of a substance.
2. Lifting effect of water upon a body entirely immersed in it.
3. Specific gravity of a solid body that will sink in water.
4. Specific gravity of a block of wood by use of a sinker.
5. Weight of water displaced by a floating body.
6. Specific gravity by flotation method.
7. Specific gravity of a liquid; two methods.
8. The straight lever: first class.
9. Center of gravity and weight of a lever.
10. Levers of the second and third classes.
11. Force exerted at the fulcrum of a lever.
12. Errors of a spring balance.
13. Parallelogram of forces.
14. Friction between solid bodies (on a level).
15. Coefficient of friction (by sliding on incline).

Light.

16. Use of photometer.
17. Images in a plane mirror.
18. Images formed by a convex cylindrical mirror.
19. Images formed by a concave cylindrical mirror.

20. Index of refraction of glass.
21. Index of refraction of water.
22. Focal length of a converging lens.
23. Conjugate foci of a lens.
24. Shape and size of a real image formed by a lens.
25. Virtual image formed by a lens.

SECOND PART.

Mechanics.

26. Breaking-strength of a wire.
27. Comparison of wires in breaking-tests.
28. Elasticity: stretching.
29. Elasticity: bending; effect of varying loads.
30. Elasticity: bending; effect of varying dimensions.
31. Elasticity: twisting.
32. Specific gravity of a liquid by balancing columns.
33. Compressibility of air: Boyle's law.
34. Density of air.
35. Four forces at right angles in one plane.
36. Comparison of masses by acceleration-test.
37. Action and reaction: elastic collision.
38. Elastic collision continued: inelastic collision.

Heat.

39. Testing a mercury thermometer.
40. Linear expansion of a solid.
41. Increase of pressure of a gas heated at constant volume.
42. Increase of volume of a gas heated at constant pressure.
43. Specific heat of a solid.

44. Latent heat of melting.
45. Determination of the dew-point.
46. Latent heat of vaporization.

Sound.

47. Velocity of sound.
48. Wave-length of sound.
49. Number of vibrations of a tuning-fork.

Electricity and Magnetism.

50. Lines of force near a bar magnet.
51. Study of a single-fluid galvanic cell.
52. Study of a two-fluid galvanic cell.
53. Lines of force about a galvanoscope.
54. Resistance of wires by substitution: various lengths.
55. Resistance of wires by substition: cross-section and multiple arc.
56. Resistance by Wheatstone's bridge: specific resistance of copper.
57. Temperature-coefficient of resistance in copper.
58. Battery resistance.
59. Putting together the parts of a telegraph key and sounder.
60. Putting together the parts of a small motor.
61. Putting together the parts of a small dynamo.

At the time of the examination the candidate must present a notebook in which he has recorded the steps and the results of his laboratory exercises, and this notebook must bear the endorsement of his teacher, certifying that the notes are a true record of the pupil's work. It should contain an index of the exercises which it describes. It is practicable for pupils to

make the original record of their observations entirely presentable, so that copying will be unnecessary, and they should in general be required to do so. This notebook will be returned at any time within a year at the request of the candidate.

CHEMISTRY.

FORMULATION VI.

The requirement in Chemistry is based on the report of the Committee on Chemistry of the Science Department of the National Educational Association.

The following outline includes only the indispensable things which must be studied in the class-room and laboratory. The material is, for the most part, common to all elementary text-books and laboratory manuals. Each book makes its own selection of facts beyond this which may be necessary for the illustration of the principles of the science. The order of presentation will naturally be determined by each teacher for himself.

OUTLINE:—The chief physical and chemical characteristics, the preparation and the recognition of the following elements and their chief compounds: *oxygen, hydrogen, carbon, nitrogen, chlorine, bromine, iodine, fluorine, sulphur*, phosphorus, silicon, potassium, *sodium*, calcium, magnesium, *zinc*, copper, mercury, silver, aluminum, *lead*, tin, *iron*, manganese, chromium.

More detailed study should be confined to the italicized ELEMENTS (as such) and to a restricted list of compounds, such as: water, hydrochloric acid, carbon-monoxide, carbon-dioxide, nitric acid, ammo-

nia, sulphur-dioxide, sulphuric acid, hydrogen-sulphide, sodium-hydroxide.

Attention should be given to the atmosphere (constitution and relation to animal and vegetable life), flames, acids, bases, salts, oxidation and reduction, crystallization, manufacturing processes, familiar substances (illuminating gas, explosives, baking powder, mortar, glass, metallurgy, steel, common alloys, porcelain, soap).

Combining proportions by weight and volume; calculations founded on these and Boyle's and Charles' laws; symbols and nomenclature (with careful avoidance of special stress, since these are non-essential); atomic theory, atomic weights and valency in a very elementary way; nascent state; natural grouping of the elements; solution (solvents and solubility of gases, liquids and solids, saturation); ionization; mass action and equilibrium; strength (= activity) of acids and bases; conservation and dissipation of energy; chemical energy (very elementary); electrolysis. Chemical terms should be defined and explained, and the pupil should be able to illustrate and apply the ideas they embody. The theoretical topics are not intended to form separate subjects of study, but to be taught only so far as is necessary for the correlation and explanation of the experimental facts.

The facts should be given as examples from various classes, and not as isolated things. Thus, to speak of a "standard method of preparing hydrogen," whereby the action of zinc on hydrochloric acid is meant, shows narrow and infertile teaching. It should be shown that all acids are acted upon by a certain class of

metals to produce hydrogen. Examples of both classes of metals should be given and the general principles derived. The reason for using zinc and hydrochloric acid in the laboratory can then be stated.

It is recommended that the candidate's preparation in chemistry should include:

(*a*) Individual laboratory work comprising at least forty exercises selected from a list of sixty or more, not very different from the list given below.

(*b*) Instruction by lecture-table demonstrations to be used mainly as a basis for questioning upon the general principles involved in the pupil's laboratory investigations.

(*c*) The study of at least one standard text-book to the end that the pupil may gain a comprehensive and connected view of the most important facts and laws of elementary chemistry.

LIST OF EXPERIMENTS.

General.

1. Composition of the atmosphere.
2. Dissociation of mercuric oxide, and study of resulting products.
3. Burning of magnesium, sodium and potassium in air, and of iron in oxygen, with study of resulting products.
4. Combination of substances produced in (3) with water, and study of results.
5. Burning of sulphur and phosphorus in air; study of products.

6. Combination of substances produced in (5) with water; study of products.

7. Treatment of substances resulting from (3) and (4) with hydrochloric acid, and examination of final products.

Laws of Gas Volumes and Vapor Tension.

8. Boyle's law.

9. Charles' law.

10. Vapor tension as related to temperature.

Common Elements and Compounds.

11. Preparation and study of oxygen.

12. Weight of a liter of oxygen under standard conditions.

13. Preparation of hydrogen by action of sodium on water. Careful study of by-product.

14. Preparation of hydrogen by zinc and acid. More thorough study of hydrogen in larger quantities; study of by-product.

15. Weight of a liter of hydrogen under standard conditions. (Optional for best students only.)

16. Proportion by volume in which hydrogen and oxygen unite. (Lecture demonstration with eudiometer.)

17. Proportion by weight in which hydrogen and oxygen combine.

18. Study of boiling point, freezing point, action on litmus, and taste of substance produced by combining oxygen and hydrogen.

19. Electrolysis of water, resulting gases being accurately measured and tested.

20. Vapor density of water, conclusion as to formula for water. (Optional for best pupils.)

21. Study of sodium, potassium, lithium, strontium, calcium, and barium compounds. Detection of presence of these metals by flame test and by spectroscope.

22. Study of salts of cobalt, copper, nickel, manganese, chromium, iron. Tests for these metals and those mentioned in 21 in unknown mixtures.

23. Study of compounds of aluminum, magnesium and zinc. Tests for these in mixtures of 21 and 22.

24. Tests for silver, lead, and bismuth in unknown mixtures of 21, 22 and 23.

25. Tests for mercury and arsenic in unknown mixtures of 21, 22, 23 and 24.

26. Preparation and study of chlorine gas.

27. Weight of a liter of chlorine.

28. Combustion of chlorine in hydrogen.

29. Preparation of hydrochloric acid and studies of properties.

30. Decomposition of hydrochloric acid gas by sodium amalgam, and conclusions as to percentage composition. Avogadro's law.

31. Preparation and study of at least three chlorides.

32. Preparation and study of bromine.

33. Preparation of at least three bromides.

34. Preparation and study of iodine.

35. Preparation of at least three iodides.

36. Comparative study of the chemism of chlorine, bromine and iodine by mutual displacement.

37. Study of hydrofluoric acid and fluorides.

38. Determination of the combining proportion of chlorine and zinc, and of the atomic weight of zinc.

39. Atomic weight of zinc from specific heat. Law of Dulong and Petit.

40. Atomic weight of silver by displacement of zinc.

41. Study of forms of sulphur.

42. Direct formation of sulphides.

43. Study of sulphurous oxide.

44. Preparation of sulphurous and sulphuric acids.

45. Preparation of at least two sulphites and two corresponding sulphates. Comparative study of these.

46. Decomposition of ammonium nitrate and study of nitrous oxide.

47. To determine the composition of nitrous oxide. Gay-Lussac's Law.

48. Preparation and study of nitric acid.

49. Preparation of three nitrates in three different ways.

50. Composition of gas formed by action of cold dilute nitric acid on copper.

51. Composition of gas formed by union of nitric oxide and oxygen.

52. Preparation of chromic anhydride, chromic acid acid and potassium chromate.

53. Changing potassium chromate to potassium bichromate and back again. Oxidation and reduction in solutions.

54. Chromium as an acid-forming and as a base-forming element. Preparation of chromium sulphate.

55. Preparation of ferrous and ferric salts.

Carbon and some Carbon Compounds.

56. Product of burning charcoal. Tests.

57. Test for presence of carbon in wood, paper, kerosene, coal gas, alcohol.

58. Preparation of three carbonates.

59. Solubility of carbonates in the presence of carbon dioxide.

60. Effect of heat on suspension of carbonates in solution.

61. Carbon dioxide from fermentaion.

62. Alcohol from fermentation.

63. Preparation of ether by alcohol and sulphuric acid.

64. Preparation of alkaline salts of fatty acids, or soap-making.

At the time of the examination the candidate must present a notebook in which he has recorded the steps and the results of his laboratory exercises, and this notebook must bear the endorsement of his teacher, certifying that the notes are a true record of the pupil's work. It should contain an index of the exercises which it describes. It is practicable for pupils to make the original record of their observations entirely presentable, so that copying will be unnecessary, and they should in general be required to do so. This notebook will be returned at any time within a year at the request of the candidate.

ENGLISH.

The requirement in English is that recommended by the Conference on Uniform Entrance Requirements in English. (N. E. Requirements.)

FORMULATION VII.

NOTE.—No candidate will be accepted in English whose work is notably defective in point of spelling, punctuation, idiom, or division into paragraphs.

(*a*) READING.—A certain number of books will be set for reading. The candidate will be required to present evidence of a general knowledge of the subject-matter, and to answer simple questions on the lives of the authors. The form of examination will usually be the writing of a paragraph or two on each of several topics, to be chosen by the candidate from a considerable number—perhaps ten or fifteen—set before him in the examination paper. The treatment of the topics is designed to test the candidate's power of clear and accurate expression, and will call for only a general knowledge of the substance of the books. The candidate is expected to read intelligently all the books prescribed. He is expected not to know them minutely, but to have fresh in mind their most important parts. *In every case knowledge of the book will be regarded as less important than the ability to write good English.* In preparation for this part of the requirement, it is important that the candidate shall have been instructed in the fundamental principles of rhetoric.

The books set for this part of the examination will be:

1901 and 1902: Shakespeare's *Merchant of Venice;* Pope's *Iliad;* Books I, VI, XXII, and XXIV; The *Sir Roger De Coverley Papers* in The Spectator; Goldsmith's *The Vicar of Wakefield;* Coleridge's *The Ancient Mariner;* Scott's *Ivanhoe;* Cooper's *The last of the Mo-*

hicans; Tennyson's *The Princess;* Lowell's *The Vision of Sir Launfal;* George Eliot's *Silas Marner.*

1903, 1904, 1905: Shakespeare's *The Merchant of Venice* and *Julius Caesar;* The *Sir Roger De Coverley Papers* in The Spectator; Goldsmith's *The Vicar of Wakefield;* Coleridge's *The Ancient Mariner;* Scott's *Ivanhoe;* Carlyle's *Essay on Burns;* Tennyson's *The Princess;* Lowell's *The Vision of Sir Launfal;* George Eliot's *Silas Marner.*

(*b*) STUDY AND PRACTICE. This part of the examination presupposes the thorough study of each of the works named below. The examination will be upon subject-matter, form, and structure. In addition, the candidate may be required to answer questions involving the essentials of English grammar, and questions on the leading facts in those periods of English literary history to which the prescribed works belong.

The books set for this part of the examination will be:

1901 to 1905: Shakespeare's *Macbeth;* Milton's *Lycidas, Comus, L'Allegro,* and *Il Penseroso;* Burke's *Speech on Conciliation with America;* Macaulay's *Essays on Milton and Addison.*

Either part of the examination may be taken separately.

Attention is called to the following recommendations of the Conference on Uniform Entrance Requirements in English:

1. That English be studied throughout the elementary and secondary school courses, and, when possible, for at least three periods a week during the four years of the high school course.

2. That the prescribed books be regarded as a basis for such wider courses of English study as the schools may arrange for themselves.

3. That, where careful instruction is idiomatic English translation is not given, supplementary work to secure an equivalent training in diction and in sentence-structure be offered throughout the high school course.

4. That a certain amount of outside reading, chiefly of poetry, fiction, biography, and history, be encouraged throughout the entire school course.

5. That definite instruction be given in the choice of words, in the structure of sentences and of paragraphs, and in the simple forms of narration, description, exposition, and argument. Such instruction should begin early in the high school course.

6. That systematic training in speaking and writing English be given throughout the entire school course. That, in the high school, subjects for composition be taken, partly from the prescribed books, and partly from the student's own thought and experience.

7. That each of the books prescribed for study be taught with reference to

(*a*) The language, including the meaning of words and sentences, the important qualities of style, and the important allusions;

(*b*) The plan of the work, *i. e.*, its structure and method;

(*c*) The place of the work in literary history, the circumstances of its production, and the life of its author.

That all details be studied, not as ends in them-

selves, but as means to a comprehension of the whole.

FRENCH.

The requirements in French follow the recommendations of the Committee of Twelve of the Modern Language Association.

(*a*) THE ELEMENTARY REQUIREMENT.

FORMULATION VIII.

THE AIM OF THE INSTRUCTION.

At the end of the elementary course the pupil should be able to pronounce French accurately, to read at sight easy French prose, to put into French simple English sentences taken from the language of everyday life, or based upon a portion of the French text read, and to answer questions on the rudiments of the grammar as defined below.

THE WORK TO BE DONE.

During the first year the work should comprise: (1) careful drill in pronunciation; (2) the rudiments of grammar, including the inflection of the regular and the more common irregular verbs, the plural of nouns, the inflection of adjectives, participles, and pronouns; the use of personal pronouns, common adverbs, prepositions, and conjunctions, the order of words in the sentence, and the elementary rules of syntax; (3) abundant easy exercises, designed not only to fix in the memory the forms and principles of grammar, but also to cultivate readiness in the reproduction of natural forms of expression; (4) the reading of from 100 to 175 duodecimo pages of graduated texts, with con-

stant practice in translating into French easy variations of the sentences read (the teacher giving the English), and in reproducing from memory sentences previously read; (5) writing French from dictation.

During the second year the work should comprise: (1) the reading of from 250 to 400 pages of easy modern prose in the form of stories, plays, or historical or biographical sketches; (2) constant practice, as in the previous year, in translating into French easy variations upon the texts read; (3) frequent abstracts, sometimes oral and sometimes written, of portions of the text already read; (4) writing French from dictation; (5) continued drill upon the rudiments of grammar, with constant application in the construction of sentences; (6) mastery of the forms and use of pronouns, pronominal adjectives, of all but the rare irregular verb forms, and of the simpler uses of the conditional and subjunctive.

Suitable texts for the second year are: About's *Le roi des Montagnes*, Bruno's *Le tour de la France*, Daudet's easier short tales, La Bedolliere's *La Mere Michel et son chat*, Erckmann-Chatrian's stories, Foa's *Contes biographiques* and *Le petit Robinson de Paris*, Foncin's *Le pays de France*, Labiche and Martin's *La poudre aux yeux* and *Le voyage de M. Perrichon*, Legouve and Labiche's *La cigale chez les fourmis*, Malot's *Sans famille*, Mairet's *La tache du petit Pierre*, Merimee's *Colomba*, extracts from Michelet, Sarcey's *Le siege de Paris*, Verne's stories.

(*b*) THE INTERMEDIATE REQUIREMENT.

FORMULATION IX.

THE AIM OF THE INSTRUCTION.

At the end of the intermediate course the pupil should be able to read at sight ordinary French prose or simple poetry, to translate into French a connected passage of English based on the text read, and to answer questions involving a more thorough knowledge of syntax than is expected in the elementary course.

THE WORK TO BE DONE.

This should comprise the reading of from 400 to 600 pages of French of ordinary difficulty, a portion to be in the dramatic form; constant practice in giving French paraphrases, abstracts or reproductions from memory of selected portions of the matter read; the study of a grammar of moderate completeness; writing from dictation.

Suitable texts are: About's stories, Augier and Sandeau's *Le Gendre de M. Poirier*, Beranger's poems, Corneille's *Le Cid* and *Horace*, Coppee's poems, Daudet's *La Belle-Nivernaise*, La Brete's *Mon oncle et mon cure*, Madame de Sevigne's letters, Hugo's *Hernani* and *La chute*, Labiche's plays, Loti's *Pecheur d' Islande*, Mignet's historical writings, Moliere's *L'avare* and *Le bourgeois gentilhomme*, Racine's *Athalie*, *Andromaque*, and *Esther*, George Sand's plays and stories, Sandeau's *Mademoiselle de la Seigliere*, Scribe's plays, Thierry's *Recits des temps merovingiens*, Thiers's *L'expedition de Bonaparte en Egypte*, Vigny's *La canne de jonc*, Voltaire's historical writings.

An examination in Advanced French, in accordance with the recommendations of the Committee of Twelve, will be given when there is sufficient demand for it.

GERMAN.

The requirements in German follow the recommendations of the Committee of Twelve of the Modern Language Association.

(*a*) THE ELEMENTARY REQUIREMENT.

FORMULATION X.

THE AIM OF THE INSTRUCTION.

At the end of the elementary course in German the pupil should be able to read at sight, and to translate, if called upon, by way of proving his ability to read a passage of very easy dialogue or narrative prose, help being given upon unusual words and constructions, to put into German short English sentences taken from the language of everyday life or based upon the text given for translation, and to answer questions upon the rudiments of the grammar, as defined below.

THE WORK TO BE DONE.

During the first year the work should comprise: (1) careful drill upon pronunciation; (2) the memorizing and frequent repetition of easy colloquial sentences; (3) drill upon the rudiments of grammar, that is, upon the inflection of the articles, of such nouns as belong to the language of everyday life, of adjectives, pronouns, weak verbs, and the more usual strong verbs; also upon the use of the more common prepo-

sitions, the simpler uses of the modal auxiliaries, and the elementary rules of syntax and word order; (4) abundant easy exercises designed not only to fix in mind the forms and principles of grammar, but also to cultivate readiness in the reproduction of natural forms of expression; (5) the reading of from 75 to 100 pages of graduated texts from a reader, with constant practice in translating into German easy variations upon sentences selected from the reading lesson (the teacher giving the English), and in the reproduction from memory of sentences previously read.

During the second year the work should comprise: (1) the reading of from 150 to 200 pages of literature in the form of easy stories and plays; (2) accompanying practice, as before, in the translation into German of easy variations upon the matter read, and also in the off-hand reproduction, sometimes orally and sometimes in writing, of the substance of short and easy selected passages; (3) continued drill upon the rudiments of the grammar, directed to the ends of enabling the pupil, first, to use his knowledge with facility in the formation of sentences, and, secondly, to state his knowledge correctly in the technical language of grammar.

Stories suitable for the elementary course can be selected from the following list: Andersen's *Marchen* and *Bilderbuch ohne Bilder;* Arnold's *Fritz auf Ferein;* Baumbach's *Die Nonna* and *Der Schwiegersohn;* Gerstacker's *Germelshausen;* Heyse's *L'Arrabbiata, Das Madchen von Treppi* and *Anfang und Ende;* Hillern's *Hoher als die Kirche;* Jensen's *Die braune Erica;* Leander's *Traumereien* and *Kleine Geschichten;* Seidel's *Mar-*

chen; Stokl's *Unter dem Christbaum;* Storm's *Immensee* and *Geschichten aus der Tonne;* Zschokke's *Der zerbrochene Krug.*

Good plays adapted to the elementary course are much harder to find than good stories. Five-act plays are too long. They require more time than it is advisable to devote to any one text. Among shorter plays the best available are perhaps Benedix's *Der Prozess, Der Weiberfeind,* and *Gunstige Vorzeichen;* Elz's *Er ist nicht eifersuchtig;* Wichert's *An der majorsecke;* Wilhelmi's *Einer muss heiraten.* It is recommended, however, that not more than one of these plays be read. The narrative style should predominate. A good selection of reading matter for the second year would be Andersen's *Marchen,* or *Bilderbuch,* or Leander's *Traumereien,* to the extent of say forty pages. After that such a story as *Das kalte Herz* or *Der zerbrochene Krug;* then *Hoher als die Kirche,* or *Immensee;* next a good story by Heyse, Baumbach, or Seidel; lastly *Der Prozess.*

(*b*) THE INTERMEDIATE REQUIREMENT.

FORMULATION XI.

THE AIM OF THE INSTRUCTION.

At the end of the intermediate course the pupil should be able to read at sight German prose of ordinary difficulty, whether recent or classical; to put into German a connected passage of simple English, paraphrased from a given text in German; to answer any grammatical questions relating to usual forms and essential principles of the language, including syntax

and word-formation, and to translate and explain (so far as explanation may be necessary) a passage of classical literature taken from some text previously studied.

THE WORK TO BE DONE.

The work should comprise, in addition to the elementary course, the reading of about 400 pages of moderately difficult prose and poetry, with constant practice in giving, sometimes orally and sometimes in writing, paraphrases, abstracts, or reproductions from memory of selected portions of the matter read; also grammatical drill upon the less usual strong verbs, the use of articles, cases, auxiliaries of all kinds, tenses and modes (with special reference to the infinitive and subjunctive), and likewise upon word-order and word-formation.

The intermediate course is supposed to be the elementary course, plus one year's work at the rate of not less than four recitations a week. Suitable reading matter for the third year can be selected from such works as the following: Ebner-Eschenbach's *Die Freiherren von Gemperlein;* Freytag's *Die Journalisten* and *Bilder aus der deutschen Vergangenheit*—for example, *Karl der Grosse, Aus den Kreuzzugen, Doktor Luther, Aus dem Staat Friedrichs des Grossen;* Fouque's *Undine;* Gerstacker's *Irrfahrten;* Goethe's *Hermann und Dorothea* and *Iphigenie;* Heine's poems and *Reisebilder;* Hoffmann's *Historische Erzahlungen;* Lessing's *Minna von Barnhelm;* Meyer's *Gustav Adolfs Page;* Moser's *Der Bibliothekar;* Riehl's *Novellen*—for example, *Burg Neideck, Der Fluch der Schonheit. Der stumme Ratcherr, Das Spielmannkind;* Rosegger's *Wald-*

heimat; Schiller's *Der Neffe als Onkel, Der Geisterscher, Wilhelm Tell, Die Jungfrau von Orleans, Das Lied von der Glocke, Balladen;* Scheffel's *Der Trompeter von Sakkingen;* Uhland's poems; Wildenbruch's *Das edle Blut.*

An examination in Advanced German, in accordance with the recommendations of the Committee of Twelve, will be given when there is sufficient demand for it.

HISTORY.

The requirement in History is based on the recommendations of the Committee of Seven of the American Historical Association.

FORMULATION XII.

(*a*) Ancient history, with special reference to Greek and Roman history, and including also a short introductory study of the more ancient nations and the chief events of the early Middle Ages, down to the death of Charlemagne (814).

(*b*) Mediaeval and modern European history, from the death of Charlemagne to the present time.

(*c*) English history.

(*d*) American history and civil government.

Each of the above topics is intended to represent one year of historical work wherein the study is given five times per week, or two years of historical work wherein the study is given three times per week.

FREE-HAND DRAWING.

FORMULATION XIII.

Exercises with straight and curved lines in the flat; pencil shading; studies relating to decorative designs,

such as book covers, wall papers, textile fabrics, floor coverings and ornamental designs for wood carvings and iron work; sketching simple objects and machine parts; principles of projection. In this work the pupil should be taught the relation of the several views of a mechanical drawing to the object represented, and to each other. As the work progresses the pupil should take measurements from the objects to be drawn and the sketch should be dimensioned according to the conventional shop methods. Exercises in plain lettering should begin with the first work in free-hand drawing and continue throughout the entire course. It is expected that this subject will require five periods per week for one year.

This requirement presupposes a general knowledge of free-hand drawing obtained in the grade schools.

DISCUSSION.

THE PRESIDENT.—It should be stated that the Secretary of the committee, Professor Flather, virtually approves the report, having made the original draft of it, and in a letter received from him, the Chairman of the committee, Professor Tyler, also virtually approves the draft made by the Secretary.

PROFESSOR MERRIMAN.—As a member of the committee, the speaker would note that there seems to be an impression among some members of the Society that this committee is investigating the subject of college examinations. The pamphlet which was sent out, containing formulations and asking if they would be satisfactory, gave rise to the impression that the subject of college examinations was under considera-

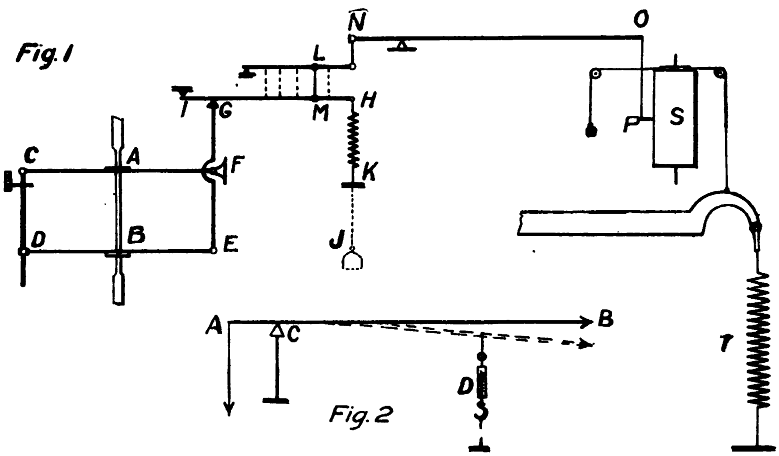
tion, and in fact a reference to this effect appeared in the preliminary draft of the report which was circulated among the members of the committee some three or four weeks ago. It was, however, the unanimous opinion of the members of the committee present at the meeting yesterday, and whose signatures appear on the report, that no authorization has ever been given to this committee to consider the subject of college examinations, but that its functions relate solely to entrance requirements and the proper formulation of the same.

A LABORATORY EXERCISE: THE CALIBRATION OF A RIEHLE-GRAY APPARATUS.

BY GEORGE R. CHATBURN,

Adjunct Professor of Civil Engineering, The University of Nebraska, Lincoln, Neb.

In the designing of instruments it sometimes happens that principles of mechanics are overlooked and large systematic errors result. To determine what these errors are and why they occur furnishes a good laboratory exercise and fixes in the minds of students



the principles which have been violated more firmly than will many other standard exercises. The following report of an exercise for calibrating a Riehle-Gray Apparatus will illustrate my meaning.

Fig. 1 is a schematic illustration of the instrument.*

* For more detailed description than here given see *Proceedings A. S. M. E.*, Vol. XIII. Mr. G. C. Henning gives a criticism of the instrument in the same volume. Also see Marten's "Handbook of Testing Materials," Henning's translation, pp. 604, 605.

The elongation of the test piece AB is greatly magnified by the system of levers and recorded on the cylinder S by the pen P. The cylinder at the same time is given a rotary movement by the raising of the weighing beam against the spring T. Another spring is attached to one of the levers at H and rigidly to the framework of the testing machine at K. This spring serves to counterpoise the weight of the lever NO and insure the lever IH following the knife-edge G as it recedes due to the stretch of the test piece AB. By changing the position of the link LM various magnifications from 40 to 1,000 are supposed to be obtained. Four springs for the position HK, duly labelled for the several magnifications, are furnished with the apparatus. Also three different springs T, rated to elongate sufficient to move the perimeter of the drum, S, one inch under loads of 5,000, 10,000, and 20,000 pounds respectively.

Having determined in the ordinary manner that for a certain bar of steel

$$E = 30{,}000{,}000$$

very nearly, a class is usually surprised to find by measurements taken from the autographic stress-strain diagram of the instrument, 300 magnification, 500 pound spring, that

$$E = 40{,}000{,}000 \text{ to } 50{,}000{,}000.$$

This very surprise creates an interest which is one of the first psychological requisites of good teaching. The laboratory exercise spoken of in the caption is then stated: "Find the cause of the discrepancy."

After talking the matter over with the class the following questions are decided upon for investigation:

1. Do the levers actually magnify 300 times?

2. Is 5,000 pounds the actual load necessary to elongate the spring *T* enough to move the pen relative to the drum one inch, and is the elongation proportional to the load?

These two questions usually furnish sufficient work for one afternoon. First, by using the trammel points of a beam compass, the levers are carefully measured and the magnification found to vary but little from the rated amount, 300. Three or four independent measurements may be necessary to settle this question. Second, a strong test bar being put in the machine, a piece of paper wrapped about the drum *S*, and the position of the pen *P*, for a zero load noted; stress is now applied until shown by the poise to be about 5,000 pounds, the spring *T* is hooked on and the poise returned to zero, and with the pen a vertical line is drawn. The process is repeated for loads of about 10,000, 15,000, etc., pounds. Two or more such records being taken their average is tabulated and plotted. In this case the plot (not given) shows the elongation to be one inch per 5,000 pounds and, being a straight line, is proportional to the load. Both of our questions have now been answered in the affirmative. *If the discrepancy is not in the leverage nor in the spring T, where is it?*

The students are allowed to think of this question until the next laboratory period. Probably some student will suggest that the trouble lies in the spring *HK*. A reason for so thinking is demanded. After

again looking over the machine, the student finding no apparent reason, the idea is usually withdrawn. The teacher then has an opportunity to say that an idea should not be abandoned until definitely proved to be worthless.

In the apparatus as made the length of the rod *CD*, Fig. 1, being threaded and passing through a nut at *D*, is adjustable. By putting a graduated disc on the rod we make a rough micrometer screw, but sufficiently accurate for our purpose. Theoretically any shortening of *CD* produces a corresponding fall in the knife-edge *G*, and is equivalent to a stretch one-half as great in *AB*. By turning the screw *CD*, changes in its length may be made at will and the results of the concomitant movements of the pen *P* noted.

Fig. 3 shows the plots of several records made in the above manner. With the magnification set for 300, curves IV and V give extremes of magnification, 232 and 240, for one spring. By using a stronger spring at *HK*, curves VII and VIII with magnifications of 110 and 94 were given. In order to get anything like uniform results it is necessary, after each turn of the screw *CD*, to tap the machine with a mallet to overcome the friction of the several parts of the apparatus. The higher the magnification the greater the effect of pencil friction. Using the values now determined we find the coefficient of elasticity more nearly agrees with what we expected. But why *the magnification is not 300 is still unanswered.*

The spring *HK* is now removed and a weight as shown by the dotted lines (Fig. 1) substituted. IX, Fig. 3, is a plot for the case in which the weight is

just heavy enough to raise the pen, about four pounds for the 300 magnification. The four-pound weight is then replaced by an eight-pound weight and another curve plotted. The observations for this curve are designated in Fig. 3 by triangular spots near the line

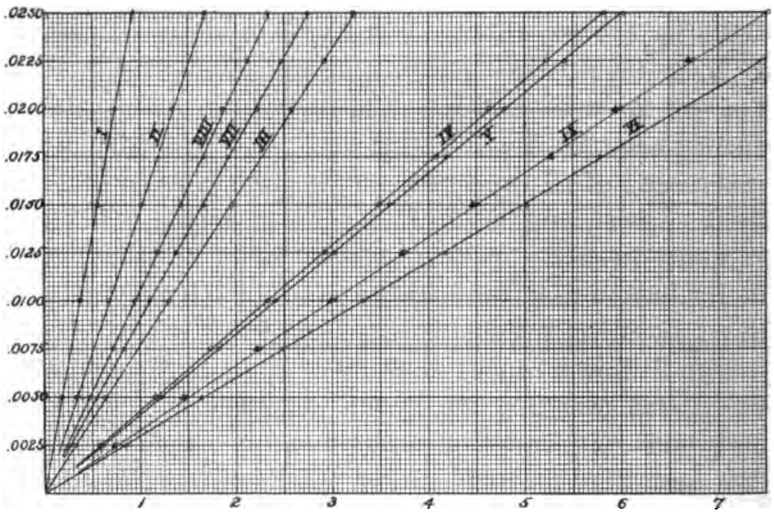


Fig. 3. The ordinates represent the stretch of test piece in inches, while the abscissas represent the movement of the recording pen in inches.

I	Nominal	Magnification	40,	Actual	37.
II	"	"	100,	"	68.
III	"	"	200,	"	130.
IV	"	"	300,	"	232, tight spring.
V	"	"	300,	"	240, loose spring.
VIII	"	"	300,	"	94, stronger spring tight.
VII	"	"	300,	"	110, " " loose.
VI	"	"	400,	"	332.
IX	"	"	300,	"	300, weight.

IX. The magnification for each of these two last sets of observations is practically the same, 300.

We have now shown that the spring *HK* is the primary cause of the error in the magnification; but the

explanation of the discrepancy is still an interesting problem to the class and generally conducive of much discussion among the members, both in and out of the laboratory. The main point to the whole exercise is that Hook's law holds in the constituent parts of the measuring apparatus, as well as in the test piece itself. The bars *CF*, *DE* and *IH* of the instrument are all stressed by the tension of the spring *HK* and hence slightly deformed. When *AB* elongates, the stresses are all relieved proportionally and the curve plotted by *P* is in like proportion altered. The portion of the magnification not imparted to the pen is taken up by partial return to the normal shape of the stressed parts. If the parts were perfectly rigid the magnification would be exactly as the ratio of the levers. When a weight replaces the spring at *HK* the magnification approaches that calculated from the levers, friction, only, preventing exact approach, for the stresses in the bars before mentioned are practically constant. Friction of the pencil, however, becomes so great under the large magnifications that we can not place any reliance in a curve plotted with these magnifications even when the spring *HK* is replaced by the weight.

If the above reasoning be not quite clear to any student, let him perform an easy experiment, thus: Make a simple lever, *AB*, Fig. 2, of any flexible elastic material and note the relative movements of *A* and *B*, both before and after attaching a spring *D*. Also for a given movement of *A*, the stronger the spring *D* the greater the bend of the lever *AB* and consequent less movement of *B*. Note too, that the motion of *B* is at

all times proportional to that of A. Compare with the results of the compound lever in the Riehle apparatus.

The above exercise has not been for the purpose of finding fault with the apparatus, which is a most excellent one for some purposes, but to show how the ordinary routine of laboratory exercises might, with advantage, be varied. The interest of the class is excited and maintained: this secures *attention* to the several details of the experiment, develops *intention* on the part of the student to thoroughly investigate the problem, and insures the *retention* of the various principles involved. Herein the laboratory is employed in the encouragement of a function which peculiarly belongs to it—original research.

PROFESSOR GRAY.—The speaker has been interested in this paper because it might appear that in the original design of the apparatus he had neglected some of the principles of mechanics. A set of apparatus similar to that described in the *Proceedings* of the American Society of Mechanical Engineers, Vol. XIII., has been in use in the Mechanical Department of the Rose Polytechnic Institute for over ten years and no difficulty of the kind mentioned in the paper has been noticed. The original design does not, however, contain the spring *HK*, referred to in the paper. This is a modification which has been introduced by the makers and, judging from the results quoted, is not an improvement. The speaker thinks, however, that attention should be given to the explicit statement made in the paper, whose reference is given above, that the constant of the apparatus should be

obtained by experiment and not from a calculation of leverages. A method of making the calibration is given in that paper.

Were the author present the speaker should like to ask what instructions Riehle Bros. sent out with the apparatus. The answer to this question would go far to determine whether they were in any way responsible for the results apparently indicated by the machine. It seems possible that the author of the paper does not quite understand how the apparatus should be used.

MACHINE WORK IN AN ENGINEERING COLLEGE.

BY WILLIAM P. TURNER,

Assistant Professor of Practical Mechanics, Purdue University, Lafayette, Ind.

The shop work of the technical school has been the subject of much discussion. The manufacturer who is keenly watching for every opportunity to increase the quantity and improve the quality of the work of his shop and at the same time reduce the cost of production, is apt to look with little favor upon the shop work of the school. The value of shop work to the student is often estimated by the amount of skill shown by the graduate when he goes into the shop and attempts to perform some piece of work. If he shows an ability to grasp the conditions and go about the work in a workmanlike way he is apt to be considered with more favor than the one who appears to be at a loss in deciding how to begin or what to do. Such a method of estimating the worth of a student is not fair, since students with equal ability may have had different methods of shop training in their respective shop courses with the result that one is better fitted along certain lines of work than another.

In the minds of many people the shop work of the high school, the manual training school, the trades school and the engineering college is a constant, involving about the same course of work in the various departments, while in reality the distinction is well marked. The shop work of the high school or the man-

ual training school is for the development of the mind; to cause the student to think and reason, to combine thought and action and so to develop the student that he may be better fitted for any general line of work which he may choose. In a trades school the purpose is quite different. The work is not given for the mere purpose of strengthening the mind but with a view to teach the student to be skillful of hand and to give him sufficient knowledge of some particular kind of work that he may be able to work at that as a trade and become master of it, thus insuring daily wages. In the college shop the conditions are again changed. The work of the college is to some extent a combination of the work of the manual training school and the trades school, while the purpose of the work is quite unlike either. No attempt is made in the college shop to make a skilled artisan who will follow one line of work throughout his life nor is the work given simply for the purpose of causing the student to think and reason. While both skill of hand and development of mind are obtained in the college shop the real work of the shop is intended for another purpose. It must put the student in touch with the practical side of his chosen profession. He must know something of the shop side of his work, of the difficulties that arise in the construction of work and the methods of overcoming these difficulties, if he would be successful. For this reason the work of the different departments of the college shop must be developed along lines quite different from those of the manual training or of the trades schools.

There is probably no other branch in the shop work

of a college which presents such opportunities for development as machine work. Here the student should become acquainted with machine shop methods; should encounter the difficulties which confront the workman in the manufacturing establishment; should learn the value of time and acquire such skill of hand as may be obtained in the short time spent at the work.

The college machine shop should be, in many respects as nearly as may be, a model of a commercial shop. Modern shop systems should be introduced; such as the systems of tool keeping, and of keeping stock and time records.

The equipment should comprise a large variety of tools and machines. Besides the lathes, planers and shapers common to every college shop, there should be types of milling machines both universal and plain, the larger ones having sufficient power to do heavy milling with special gang mills. There should be turret machines for turning heavy castings or large rods; hand screw machines and automatic screw machines; grinding machines for grinding and finishing cylindrical and tapered work; surface grinding machines and cutter grinders; boring mills; and power presses, whereby some of the possibilities in stamping and pressing metals may be taught. While it would be impossible to represent all the different types of machines in any one shop, it is desirable to have as great a variety as possible. The tool room should be well equipped with a good line of small tools, standard gauges, etc. A shop thus equipped would be prepared to begin to do good work.

The course of work in the college shop must for the present necessarily begin with simple exercises which will involve the use of the various machines. Each exercise should require little time in order that an undue amount of time may not be spent on mere exercises. Besides the first simple exercise there should be another line of work which should be the principal one. This should involve such work as the making of some machine or piece of apparatus, the making of which should be conducted according to manufacturing methods. The various parts of the chosen machine should be made by the students, special tool and jigs being provided whereby the work may be quickly and accurately done. Such a line of work gives the student a knowledge of the value of special tools and jigs, which is very desirable. Whenever special tools or jigs may be used for making a piece it is desirable that such tools be made. Much of this kind of tool and jig making can be done by the students during the latter part of the course, thus giving them an opportunity to do some fine tool-making. Finally the erecting and assembling of the parts into a finished machine takes place. This kind of work is very valuable to the student since it causes him to realize the necessity of making the parts accurately. When he attempts to assemble parts which he or some one else has made and finds them too large or too small, he realizes more fully than ever that the dimensions on a drawing really mean something.

Too much attention, however, cannot be given to that part of the work which develops methods, methods which are practical and economical, which show

how to make ten pieces in the time originally consumed in making one and at the same time to make each piece better and all the pieces alike. For example, consider the method of boring a shaft collar. This may be bored to exact size by the use of the forged boring tool, but who would use the forged tool when chucking reamers of the right size are at hand? It is well to teach the student the use of the forged tool, which may be used in special cases when odd sizes are to be bored or when holes are to be started to run very true, but in most cases the chucking reamers are the most desirable and the most profitable tools. Again, consider forming pieces of irregular outline. If it is lathe work, a template may be made and each piece turned by the use of hand tools until it fits the template, but who would use hand tools for such work when forming tools with cutting edges of the exact shape will do the work so much better and quicker? The same principle is true for such classes of work as may be done on the milling machine by the use of irregular forming cutters.

The use of special fixtures for holding pieces of work securely while being operated upon by the planer or milling machine, or of special drilling jigs by the use of which holes may be drilled and located with a definite relation to each other is also desirable. It is well that the student should know something about clamping work on the planer or similar machines by the use of bolts, clamps and packing blocks but he can never appreciate the value of a special clamping fixture until he has used one. Then he will appreciate the value of the fixture in its saving of time in setting the

work; and when he realizes that because of the rigidity with which the work is held, it is possible to take heavier cuts, he will appreciate the fixture still more.

These are a few of the many ways in which the use of special tools and appliances may be demonstrated in the shop.

In selecting the kind of machines or tools which are to be made the special line of work conducted on manufacturing principles, much care should be exercised. Only one or two kinds of machines should be attempted and these should not be very heavy in parts or intricate in design. Having selected a machine to be built, that selection should be adhered to from year to year, making such improvement in design and construction as may suggest themselves from time to time.

It is the custom in some college shops to build some new style of machine each year; consequently one finds them building steam engines of variously estimated horse powers with complicated valve mechanisms; dynamos, motors, engine lathes and a variety of similar articles. Such a variety of work will not yield the best results. There are two principal objections to this method: First, the finished machine seldom equals in quality of workmanship a similar commercial machine; and second, it is necessary in the construction of its parts to resort to methods which would not be tolerated in any well-regulated shop. When a student is obliged to resort to obsolete or primitive methods in constructing a piece because of the lack of suitable tools and appliances he is taking a step in the wrong direction. Unless the proper tools and jigs

can be used it would be better to adopt the simple exercises which could be adapted to the machines and appliances at hand.

It is argued by some that it is not well to have too many special tools and appliances for the student as it leaves nothing for him to do but to follow the routine course and "grind" out a number of finished pieces which will be perfect because of the special tools used in their construction. It is further argued that with this method there is no opportunity for thought in developing the method of construction or for the personal equation of skill to enter. This argument might have some force if the students were to spend days and weeks upon the same kind of work; but such is not the case. Only a short time is spent on each kind and during that time there are enough new things occurring to keep their minds well occupied and constantly on the alert for something new. Only after the student has become fully acquainted with all the conditions and the reasons for following a prescribed method in making a piece will his interest lag.

The theory that it is a good thing to let a student work out his own methods in constructing a piece is a good one within certain limitations. It is well for the student to give some thought to the method of construction before starting on a new piece of work, but when the time comes for beginning the work he should receive careful instruction. Time should not be wasted in allowing him to "tinker" according to his own notions unless they happen to be exceedingly good ones. The time for his "tinkering" was in his own

home in some back shed before he left for college. Once in the college shop he is to get new ideas as fast as he is able to comprehend them.

In most colleges there are many difficulties in the way of equipping a shop and following such a course of work as has here been outlined. The first in importance is the cost of equipment and the next is the cost of maintenance. Few colleges are willing or able to furnish many special types of tools or machines and it is often difficult to secure a sufficient number of the simpler machines to accommodate all of the students. Whenever it is possible to improve the equipment an additional expense is necessitated for its maintenance, and whenever manufacturing methods are adopted involving the use of special jigs and appliances whereby finished work may be rapidly produced, then the cost of the stock is greatly increased. This condition of affairs greatly handicaps the college shop. With the manufacturers this problem presents itself: Given a quantity of stock, how quickly can it be made into finished pieces? With the college shop the problem is: Given a limited amount of stock, how long can it be made to last? When the college shop is confronted by such a problem it is not to be expected that the highest class of work will be attained or the best methods pursued.

In many cases the college shop can be conducted so as to eliminate largely these difficulties which arise from the cost of maintenance or the cost of material. When the shop reaches that stage where it is possible to complete articles suitable for the market, then these articles may be disposed of at the market price and

bring sufficient returns to pay for all stock and material used in the shop and to add occasionally a new machine to the equipment. There are many things, however, which must be considered before attempting to put finished articles on the market. The quality of the article must be considered. It must be equal or excel in workmanship or design similar articles already on the market.

It must be remembered that the work of the shop is intended to teach the student how to do a piece of work and after he learns how he tries some other piece, consequently there are likely to be some pieces unfit for finished machines. The inspection of the pieces and the final adjusting and testing of the finished machine should be done by some one experienced in that work. While the student may do much erecting and assembling it is not safe to trust to his judgment in the final adjustment; consequently there should be one or more journeymen regularly employed in the shop to look after the final adjusting and inspecting of the finished product and also to finish such odd work as may be left unfinished by the class at the end of its term of work.

With proper supervision it ought not to take long to put the college shop on a working basis whereby it could produce marketable articles. Some shops are already successfully doing such work.

One fact, however, must not be lost sight of, namely, that the college shop is for the purpose of teaching the student principles and methods and is not a manufacturing establishment. There is a danger that when the manufacturing methods are adopted the desire to

produce quantity will cause the educational side to be neglected. This tendency must be carefully guarded against and the educational side must constantly be kept uppermost

In advocating such an advanced course of work as above indicated for the college shop it is not intended to imply that the elementary principles of machine work be neglected in order that a line of commercial work may be attempted. The first principles of machine work, involving such problems as the best shapes of tools, the methods of setting tools, methods of holding and clamping work, the best cutting speeds and feeds must be taught and instilled into the student at first. If he has not been taught these principles before entering college then he must learn them when he begins his work, but it would be far better if the college shop were not obliged to begin its work at the very bottom of the course. The time ought not be far distant when the college shop may drop the work of the manual training school and take up this more advanced work which is more in keeping with the other courses of the college. When this is done the elementary work of the high or manual training schools will be one of the requirements for entrance to an engineering college. With such preparation the student will be enabled to begin his shop work higher in the course and thus reach a higher point than he would otherwise. He would then have a better understanding and a firmer grasp of those principles of the work which will be most beneficial to him when he enters his chosen profession.

TRADES TRAINING FOR NON-TECHNICALLY EDUCATED MEN.

BY JOHN G. D. MACK,

Assistant Professor of Machine Design, University of Wisconsin, Madison, Wis.

The State University is under obligations to the commonwealth which are not felt by educational institutions of independent endowment; created by the state, supported by the people of the state, its advantages and influences should be made as far-reaching as possible.

As an example of the dissemination of trades knowledge among the people of the state, may be cited the work now being carried on in agriculture and its allied industries. For a number of years short courses in Agriculture, Animal Husbandry, Dairying, etc., have been given to practically all those who have had the ambition to acquire such knowledge. During the past fifteen years there has been an ever-increasing demand from those engaged in other industrial pursuits, for trades training applicable to their special needs. To meet this demand there has been established at the University of Wisconsin a school for Apprentices and Artisans, which opens July 1st, the first session to continue six weeks. The plan of this school, which originated with Dean J. B. Johnson, has been worked out, and will be carried on, under the direction of the College of Engineering.

That there is a great need for training of this character is clearly shown by the large enrollment of the

correspondence schools. These schools have exerted a powerful influence in assisting men to study along their own and other lines of work.

The School for Apprentices and Artisans, while bearing in its courses of study some relation to those of the correspondence schools, is not in opposition, but should rather be considered as supplementary to the latter. From the nature of their instruction the correspondence schools cannot give shop or laboratory practice, but persons attending the School for Apprentices and Artisans, and having a fair knowledge of the theory of certain lines of practice, may spend their entire time in the shops or laboratories if they choose, and so put into practice or prove experimentally the scientific principles learned from books or from the correspondence school. Another great advantage of the new school is that of personal instruction, under which system many points can be brought up in discussion which would not appear in a written correspondence.

As an illustration, the central station man, who, by means of correspondence instruction, or otherwise, has become familiar with methods of testing, could here perform the experiments relating to them and become proficient in the use of the necessary instruments. If he has not had the preliminary instruction he can obtain both this and the instrumental practice during his course, and he would also have the opportunity of devoting a portion of his time to other subjects likely to be of value to him, such as mechanical drawing, transmission of power, or experimental work relating to engines and boilers.

The School for Apprentices and Artisans has been established for the benefit of machinists, carpenters, sheet metal workers, and electricians; stationary, marine and locomotive engine men; shop foremen and superintendents, superintendents of water works, electric light and gas plants, power stations, factories, and large office and store buildings; for business men interested in technical affairs, and for young men who wish to qualify themselves for such positions. For these employments the full four years' professional courses in engineering are not required, and yet to satisfy the present demand made upon this class of men it is necessary for them to obtain a certain amount of technical knowledge. In the case of apprentices the purpose of the school is to give them a theoretical and practical instruction in the line of their trade, which they would not get in the shops, but it is not the purpose of the school to give the shop practice which they are expected to receive in serving their apprenticeship.

The machine trades lie at the basis of all manufacturing, and superiority in these very largely sustains our modern national prosperity. The practical abandonment of the apprenticeship system, also, as a result of the very general adoption of labor-saving machinery, and the common practice of confining a workman to the operation of a single type of machine, leaves our young men with no means of acquiring that wide and thorough knowledge of the machinist's trade which formerly they could obtain in the workshops by a long apprenticeship. For these reasons some new kind of industrial education becomes im-

perative. Some examples may serve to illustrate the advantages to be derived in special cases. A person may be employed in connection with, or have an interest in, a manufacturing business, without having had training or experience in mechanical matters. He would be able to obtain in our summer school an insight into the general principles and operation of machinery, engines, boilers and electrical or other apparatus.

A man in charge of or employed in an electric plant would have an opportunity to become familiar with the use of electrical measuring instruments and with methods of electrical testing. He would also have opportunities for experimental practice with the indicator, calorimeter, and other instruments used in the testing of engines and boilers; such knowledge would enable him to operate his plant more efficiently, and, therefore, more economically. An expert machinist may desire a knowledge of mechanical drawing in order to fit himself as a designer. His needs would be met by the courses which have been provided in mechanical drawing. These few examples serve to show the scope of this new school.

The following "departments of work" are provided for in the current session:

I. Courses in Engine and Boiler Practice.

1. Lectures on the Elementary Theory of Heat.
2. Lectures on Steam Engines and Boilers.
3. Experimental Work in Steam Laboratory.
4. Operation and Management of Engines and Boilers.
5. Gas and Gasoline Engines.
6. Traction Engines.

II. Courses in Applied Electricity.
1. Dynamos and Motors.
2. Electric Wiring.
3. Meters, Transformers and Lighting.
4. Telephone Service.
5. Electric Battèries.
6. Electric Station Records.
7. Elementary Theory of Alternating Currents and their Applications.
8. Electroplating and Electrotyping.

III. Machine Design.
1. Use of Elementary Formulæ.
2. Mechanical Drawing for Artisans.
3. Mechanical Drawing for Manual Training Teachers.

IV. Materials of Construction and Mechanical Transmission of Power.
1. Lectures on the Properties of Materials.
2. Tests of the Strength of Materials.
3. Tests of Lubricants.
4. Transmission of Power.

V. Shopwork.
1. Bench and Machine Work in Wood.
2. Foundry Work.
3. Bench Work in Iron.
4. Production of Flat Surfaces and Straight Edges.
5. Machine Work in Iron.
6. Practice with the Planing and Milling Machines.
7. Forge Work.
8. Tool Making.

9. Practice with the Lathe and Milling Machines.
10. Machine Construction and Pattern Work.

These courses are described more in detail below.

COURSES OF STUDY.

The lectures will assume a certain fund of practical information on the part of the students, but they will be made clear and practical, and any scientific laws relating to electricity, magnetism, thermodynamics, mechanics, physics, strength of materials, etc., which are applied, will be explained at the moment of application. The effort will be to make the lectures and the applications clear to the classes, rather than to cover a large amount of ground in any session. The time given to each course also will depend upon the preparation and needs of the class.

I. COURSES IN ENGINE AND BOILER PRACTICE.

1. Lectures on the Elementary Theory of Heat.
2. Lectures on Steam Engines and Boilers. These lectures will also include the economical production of steam and the heat value of fuel.
3. Experimental Work in Steam Laboratory.
   (*a*) Erecting and adjusting engines.
   (*b*) Setting of valves.
   (*c*) Practice with the indicator.
   (*d*) Testing of instruments used in boiler and engine tests.
   (*e*) Testing of engines and boilers.
   (*f*) Testing of injectors.
   (*g*) Testing of refrigerator plant.

4. The operation and management of engines and boilers. Lectures and practice work.

5. Gas and Gasoline Engines. Lectures and experimental work in laboratory.

6. Traction Engines. Their care and management, with experimental work.

II. Courses in Applied Electricity.

1. *Dynamos and Motors.*

(*a*) Management and testing of electrical machinery.

(*b*) Electrical measuring instruments, their use, and their abuse.

Lectures properly illustrated by typical drawings, models, and parts of machines and instruments; laboratory instruction in the proper handling of machines and instruments. It will be assumed that the classes in this course are acquainted to a greater or less extent with the practical operation of electrical plants, but the lectures will include such an amount of the theory of the flow of electric currents and their magnetic effects as seems desirable or necessary to fully explain the practical applications.

2. *Electric Wiring.*

(*a*) Electrical fittings and underwriters' requirements.

(*b*) Testing of electrical circuits.

Lectures on electrical fittings and electrical wiring, illustrated by sketches, models, and examples of typical work, with an explanation of the reasons for the various processes and rules. Testing of conductivity and insulation, and the location of grounds, in the laboratory.

3. *Meters, Transformers and Lighting.*

(*a*) Electric meters and transformers.
(*b*) Electric lamps and their economical use.
(*c*) Photometric and economy tests on electric and gas lamps.

Lectures on the methods of testing and the selection and best arrangements of meters, transformers, and lamps of various types. Work in laboratory: calibrating meters; testing core and copper losses, regulation, heating, etc., of transformers; the effect of location on illuminating power of electric lamps; photometrical economy and life tests of arc and incandescent lamps and gas lamps.

4. *Telephone Service.*

(*a*) Telephones and telephone plants.
(*b*) Switchboards and circuits.

Lectures on the organization and operation of telephone systems; the characteristics of telephone apparatus and duties of inspectors.

5. *Electric Batteries.*

(*a*) Primary batteries.
(*b*) Storage batteries.

A few lectures on the characteristics of batteries and work in the laboratory in testing the durability and adaptability of various types of cells.

6. *Electric Station Records.*

(*a*) Elementary lecture on the operation of electrical generating plants explaining the sources of wastes, the tests for detecting them and the means for

reducing them. The lectures will be illustrated by the results which are obtained in well-handled stations of various types.

(*b*) Station records and their uses.

7. *Elementary Theory of Alternating Currents and their Applications.*

Lectures with demonstrations and illustrations on the flow of alternating currents, their various effects, and their applications.

8. *Electroplating and Electrotyping.*

(*a*) Lectures on the laying out and operation of outfits.

(*b*) Practice work in laboratory.

III. Courses in the Department of Machine Design.

1. *Use of Elementary Formulæ.*

This course is intended to give a knowledge of the applications of arithmetic to the solution of problems in gearing, belting, steam engine and electrical work, etc. It includes practice in the reading and application of formulæ in the solution of practical problems, the use of handbooks, slide rules, and other methods of making computations. This course is supplemented, as are the others, by a series of lectures.

2. *Mechanical Drawing for Artisans and Apprentices.*

Lettering, use of instruments, mechanical drawing, with special attention to shop drawing, tracing and blue-printing, elementary architectural drawing, and

the laying out of sheet metal work; the above to be followed by such work in the design of machinery as the student's progress warrants.

Practice in drawing, as required by the United States Patent Office, may be taken by those having had sufficient practice in mechanical drawing.

3. *Mechanical Drawing for Manual Training Teachers.*

The use and selection of instruments and materials, lettering, geometrical construction, intersection of solids and development of surfaces, mechanical, isometric, and perspective drawing, tracing and blue-printing.

Instructions will also be given in free-hand sketching.

IV. Materials of Construction and Mechanical Transmission of Power.

1. *Lectures.*

Lectures will be given upon the properties of iron, steel, and other metals; and of wood, stone, brick, and cement.

2. *Tests of the Strength of Materials.*

A course of laboratory work will be offered which will consist of the determination of the strength and other qualities of the different materials of construction. The work will include tension, compression, bending, torsion, and shearing tests of wrought iron, cast iron, steel, wood, etc.

3. *Testing of Lubricants.*

This course consists of the testing of lubricating oils, with a view of determining their commercial value.

The laboratory investigations will include friction tests, the determination of viscosity, specific gravity, flash-point, etc.

4. *Transmission of Power.*

The course treats of the determination of transmission losses from the source of power to the resistance to be overcome, as in the case of belts, ropes, gearing, friction clutches, etc.

V. Shopwork.

The opportunities offered for instruction in the machine shop, and its coördinate departments, are along the lines involved in all the fundamental processes for the production of machinery.

The courses provided are as indicated above under "Departments of Work." In general the regular courses given to students in the College of Engineering will be offered. However, those who choose to pursue further any of the special lines of work indicated in the schedule, may have an opportunity for so doing in so far as their qualifications and the equipment will permit.

Entrance Requirements.

In order that the Summer School for Apprentices and Artisans may be of benefit to the greatest number, no requirements for entrance have been fixed beyond a knowledge of the English language and elementary arithmetic.

No Diplomas Given.

No diplomas or formal certificates will be granted to persons taking the work in the University of Wisconsin, but letters will be given by the Dean of the

College of Engineering stating what work has been taken and the proficiency attained.

The Teaching Force.

The teachers in this summer school have been selected from the regular staff of the College of Engineering. A sufficient number of these are detailed to this work to provide the necessary instruction for those who attend.

This project has received favorable comment from the press, the technical papers, and from prominent educators and business men throughout the country. If there is a sufficient demand for technical training of this character it is proposed that schools be established in the manufacturing centers of the State of Wisconsin in which instruction of the character described be given exclusively, in short terms, throughout the year.

Discussion.

Professor J. B. Johnson.—The speaker wishes to say that when he left Wisconsin about a week ago they had over fifty applicants of all ages and conditions, coming from Virginia to Dakota.* The charge for tuition is fifteen dollars and five cents an hour for all laboratory and shop instruction. The University appropriated one thousand dollars and that with the tuition will presumably just about meet expenses. Letters explaining the condition of those applying are very interesting; they are of all ages, from high

*** There were only forty who took the full six weeks' work. They were very enthusiastic in their work and thought they got great benefit from the course.—J. B. J.**

school boys who want to get a little manual training work, up to regular mechanics.

PROFESSOR C. M. WOODWARD.—It is hoped that some one will make a very careful report next year on what is accomplished this summer. It is certainly a very interesting experiment. The speaker is not at all sanguine as to its success, but thinks that if out of those seventy who reported that they would like to come, fifty of them show up they will do pretty well.

PROFESSOR MAGRUDER.—The speaker wishes to know what grade of instructors were detailed to do this extra summer work; also something as to their remunerations, that is, are they to be paid a definite amount for the work done, or will they receive only their pro rata of the fees received from the students taking the work, as is the usual practice in summer school work?

PROFESSOR JOHNSON.—There is a fixed scale for the teachers in the six weeks' summer session; a full professor gets $300, an assistant professor $225, and an instructor $150. These obtain in this summer school also, except that there were two student instructors who received less.

PROFESSOR WOODWARD.—Are the students supposed to put in six days a week?

PROFESSOR JOHNSON.—Five and a half days, leaving Saturday afternoons free.

PROFESSOR MAGRUDER.—How many full professors are detailed?

PROFESSOR JOHNSON.—One full professor, three assistant professors and five instructors. The salary list will run to fifteen or sixteen hundred dollars for the six weeks.

[The following reports are inserted as an appendix to Professor Mack's paper in order that the members of the Society may know the result of this educational experiment without waiting for a special paper on the subject at the next annual meeting. Professor Mack's report to Dean Johnson has been slightly abbreviated—Editors.]

DR. E. A. BIRGE, Acting President,
University of Wisconsin.

Dear Sir:

I beg to submit herewith the report of Professor Mack, chairman of the faculty of the Summer School for Apprentices and Artisans, on the work of the first session of the school. This school was purely an experiment in industrial education. It had seemed to me that this college could render a service to stationary engineers, superintendents of power stations, machinists and artisans of various trades, in the way of teaching mechanical drawing, the use of simple mathematical formulæ, the scientific uses of steam and electric power and of machine tools. The proposition to do work of this character, using a part of our regular teaching staff, during six weeks of the summer vacation, was approved by the Board of Regents at their meeting in January last and one thousand dollars appropriated to pay in part the expenses. A fee of fifteen dollars was charged, and laboratory and shop fees of five cents per hour for all work taken in this way. This income proved just sufficient to cover the cost of instruction and of material consumed.

A prospectus was prepared early in the calendar

year, outlining the work which would be offered, and several thousand of these were sent out. One correspondence school addressed for us over two thousand of these to its students in the State of Wisconsin. The trade journals also took up the matter and gave liberal notices, and often editorials, concerning this new departure in technical education. The result was a very considerable correspondence, a liberal call for the prospectus and an early promise for the success of the undertaking. Two causes acted, however, to reduce our numbers. The school came in the busiest season for all industrial workers, and the necessary traveling expenses served to keep many from coming from a distance for so short a term. The necessary expense of the course, including living expenses, was not less than fifty dollars, and for a number of those who attended the traveling expenses were as much more. This made the six weeks' instruction come pretty high.

Evidently the proper place for such a school is in a manufacturing city, and it should be in operation the year round, the terms being short, as from six to eight weeks. The fact that we are a state institution, however, seems to place upon us the obligation to do for this class of industrial workers whatever lies in our power, even though situated as we are in a small city with few industrial interests.

Professor Mack's report contains full information concerning the operation of the school, the numbers in attendance, their vocations, etc., and I have appended thereto extracts from letters I have received from several of the students who attended. These last show a

very high appreciation of the benefits received from the course, the only criticism offered being that the term was too short.

I may say that the numbers in attendance were sufficient to keep the teaching staff fully employed. Larger sections in the steam and electrical laboratories would require additional instructors.

I wish here to express my grateful appreciation of the enthusiastic support given to this educational venture by the teaching staff who had the work in charge. In spite of the excessive heat which Madison experienced throughout July, the work was carried on from eight to ten hours every day, except on Saturday, when the forenoon only was taken. The students of the school were a unit in praising the unremitting efforts of the instructors in their behalf.

In view of the pronounced success of this our first trial of this kind of assistance to the industrial workers of the state, and of the very salutary influence it has had in engaging the interests of these classes as well as of their employers in the work of the University, I recommend that the school be continued as a "summer school for apprentices and artisans" until some other provision be made for this class of technical workmen. If this be done, I think another appropriation of $1,000 should be made to cover the expenses. I would then have the work arranged in two sequence courses so as to provide for attendance for two sessions in the same department. By continuing the school on this basis, under its present title, and without the granting of any formal certificates, there will be no danger, I think, of confusing its work with

that of the regular courses in the College of Engineering.

I may say, in closing, that this school has attracted wide attention from other colleges of engineering and it now seems clear that a number of them will at once inaugurate similar summer schools and probably with the same titles.

Respectfully submitted,

J. B. JOHNSON,

Dean of the College of Engineering.

October 21, 1901.

DEAN J. B. JOHNSON,

College of Engineering,

University of Wisconsin.

Sir: I have the honor to submit the following report of the first session of the Summer School for Apprentices and Artisans held under the direction of the College of Engineering, from July 1 to August 9, 1901.

This school being a new departure in education, required a very careful planning of its work by the faculty of the College of Engineering some months in advance, and no material change in these arrangements was found necessary in the operation of the school.

The corps of instruction, principally from the regular faculty of the College of Engineering, was as follows:

The Assistant Professor of Machine Design, Chairman of the Faculty of the Summer School for Apprentices and Artisans, Elementary Mechanics and Mechanical Power Transmission.

The Professor of Mechanical Practice, Shop Work.

An Assistant Professor of Experimental Engineering, and an Assistant, Steam Engineering.

An Assistant Professor of Electrical Engineering, Applied Electricity.

An Instructor in Machine Design, Mechanical Drawing and Manual Training Methods.

A Fellow in Electrical Engineering, Assistant in Applied Electricity.

An Instructor in Forge Practice, Forge Work.

An Instructor in Machine Work and one in Wood Work.

The number of students registered in the School for Apprentices and Artisans was 45, of which number 28 may be considered as typical students of the classes for whom the school was projected. The remaining 17 were principally regular students of the College of Engineering who took advantage of the facilities of the summer school in order to make up shop work. Among the 28 typical students above referred to, the following occupations were represented: Draftsman, Inspector of Railway Motive Power, Professor of Mechanics in Engineering School, Professor of Mathemathics in Engineering School, Teacher of Manual Training, Machinist, Central Electric Station Employee, Gas Works Employee, Engine Shop Foreman, Lineman, Stationary Engineer, Machine Shop Apprentice.

The division of students among the courses was as follows:

Dynamo Laboratory,	28
Steam Laboratory,	22

Testing of Materials Laboratory,	4
Shop,	25
Mechanical Drawing,	10
Manual Training Seminary,	4
Elementary Mathematics,	6

The students were advised to attend lectures in other courses than those in which they were registered, and this plan was followed by a large proportion of the students. In the class-room work the time was devoted entirely to lectures as the time was too short to allow any of the periods being used for recitations. The object of the instructor in each study was to select the portions of his subject having the greatest bearing on the conditions met with in practice, and then to present these portions in as clear a manner as possible, making use of the minimum of mathematical formulæ on account of the wide variation in the preparation of the students. In the laboratory work, divisions of small number must be arranged as no time can be used for preliminary practice with the instruments which must be constantly under the eye of the instructor. It was found by the faculty, working as they did under the above conditions regarding class-room and laboratory work, that a large and satisfactory amount of ground could be covered in the six weeks' period.

Many of the students had had correspondence-school instruction, which was well supplemented by the summer-school work. In case a student had had this correspondence instruction or preliminary training of equal grade, it is believed that he could spend his time profitably in attending two sessions of the Summer School for Apprentices and Artisans. While un-

necessary at the first session, it is recommended that at coming sessions a portion of the studies be divided into an elementary and an advanced grade. This would provide for those attending a second session as well as for the widely varied preparation among those attending but a single session.

It is believed that the expectations of the School for Apprentices and Artisans were fully realized and the practical value of this form of education demonstrated. The principal source of information from which this conclusion has been drawn has been the reports of the students of the school, many of these being men of experience in their trades and professions. Several expressed an intention of returning next year, and all pronounced the work they had received as eminently satisfactory.

Respectfully submitted,

(Signed) JAS. G. D. MACK,

Chairman of the Faculty of the Summer School for Apprentices and Artisans.

REPORT OF THE COMMITTEE ON STATISTICS OF ENGINEERING EDUCATION.

BY WILLIAM T. MAGRUDER, CHAIRMAN.*

The desirability of the appointment of a "standing committee on statistics of engineering education" was suggested to the council at the New York meeting, and Professors Magruder, Reber, Talbot, Tyler and the President and Secretary, *ex officio*, were duly appointed. The committee have been unable to have any formal meetings, but as the result of some correspondence, they desire to present a preliminary report, and ask for suggestions as to what statistical investigations are especially desired, and also for the personal assistance and coöperation of the members of the Society.

Most of us know that every few months we receive requests to answer a series of questions, and that frequently these lists of questions are very similar and that not infrequently we have an inward assurance that the sender seldom gets the expected information even if replies are received. The members also know that it would take hours, and even days, to properly and correctly answer some of the questions that have been asked in circular letters. Again, members who have propounded lists of questions have been amazed at the total absence of a reasonable understanding of what were thought to be simple and plain questions.

* The full names of the members of the committee are given on page v.—EDITORS.

For example, two years ago a member of the committee sent out a printed list; and one question was, "In what department are freshman and sophomore drawing taught?" The president of a prominent engineering college replied, "There is no such department." As a matter of fact, the school has a "professor," an "assistant professor" and an "instructor" in the "Department of Mechanical Drawing." Or, again, in an engineering college having 337 engineering students by the catalogue, 275 of them are pursuing courses in civil engineering and 234 are pursuing courses in mechanical engineering. From these examples, it is apparent that the correctness of any statistics which the committee may gather should be vouched for by a member of this Society, and not by the stenographer or clerk of some busy president of a university whose engineering college is but a small part of the whole institution; for, unless the data collected are accurate, they will not only be valueless but misleading and unfair.

The committee are aware that trustees, faculties and professors may with good reason object not only to the publication, but to the dissemination of many facts concerning what may be considered to be their private affairs. It is thought that this will probably be more frequently met with in the privately endowed institutions than in those colleges which receive appropriations from the general and state governments and which publish annual reports of their receipts and expenditures.

The committee wish it distinctly understood that, as a committee, they have solicited no statistical data

whatsoever, and that the data now in the hands of the committee have been privately collected.

It is believed that professors and college authorities will be much more likely to devote the necessary time to collecting the data for replies to questions when they understand that the questions are put forth by a committee of this Society, than if they came from an individual and were to be used only by him and as he saw fit.

It has been suggested that statistics of the following subjects may possibly be, not only of much interest, but of much value to the members:

1. The numbers of undergraduate students, of graduates and of alumni, from year to year, in the different engineering departments of the different colleges. These figures have been collected for certain of our colleges and have been exhibited at the different expositions.

2. The number of buildings used strictly for engineering purposes.

3. The valuation of equipment used strictly for engineering purposes.

4. The number of teachers employed in the instruction of engineering students.

5. The amount of floor space required, and the amount at present used, per student, in the different drawing rooms, laboratories and shops.

6. The maximum number of students which could be cared for at one time in the different drawing rooms, laboratories and shops.

7. The number of students per instructor in the different departments.

8. The time assigned to different subjects in the course for lectures, for recitations, and for drawing, laboratory or shop practice.

9. The sources and amounts of revenue.

10. The annual expenditures for salaries and other expenses of instruction, for equipment and for general and administrative expenses.

11. The total expenditures, and the expenditures per student, in engineering, in arts, in science, and in agriculture of the different universities. Certain of our colleges have, in the reports of their faculties, presidents and Boards of Trustees, much of the data here enumerated collected and already published.

[Free-hand graphical illustrations of certain statistics which were in the hands of the committee were reproduced on the blackboard and elicited some discussion.]

ABSTRACT OF THE DISCUSSION.

PRESIDENT McNAIR called attention to the confusion caused by the different terms used to indicate the divisions of a university, and presented the side of the busy professor who was good natured enough to try to reply, in the five minutes at his disposal, to a set of questions, when they perhaps deserved much more time.

PROFESSOR MERRIMAN thought that the trouble arose from a misapprehension of the questions, and suggested that when the committee sends out questions, they should define such terms as department, course, school, college, term, period and hour.

PROFESSOR J. P. JACKSON assumed that the committee intended to try to differentiate the statistics re-

ceived, so that it would be possible to tell what the average technical college has and spends per annum in the way of equipment, buildings and teaching force per student. He stated that such statistics were most important to enable him to decide just what his department's share was as compared with others. He reminded the members of the paper which he had presented at the Columbus meeting of the Society requesting some such tabulation of facts.

In reply, it was stated that, from the statistics gathered by Professor Reber, it was thought that it could be shown that these figures for different colleges differ greatly, and that a large institution with one hundred students in mechanical engineering would spend less money per student than would a smaller one with thirty students. That there had to be a head professor—for either thirty students or for one hundred. At institutions of the same size, the cost depended somewhat on the way the work in the laboratories, shops and drawing rooms was divided, and that in differentiating one college from another great care must be used lest erroneous conclusions be drawn from half-digested facts.

Professor Allen was of the opinion that one can get a much better idea of what he is going to do with the statistics after he sees how they come out. The compilation of statistics sometimes lands one in a place where he simply has not anything that he can confidently present. As to the comparative cost of caring for thirty and for one hundred students, he thought that statistics might show that while it might cost no more to take care of one hundred students than

it did to care for thirty, yet it might cost three times as much to take care of two hundred as it did for one hundred. The indications in some institutions are that the more students you have the more it costs per student to educate them.

PROFESSOR GRAY said that for a number of years he had received several applications every year for statistics and that the application of these statistics and the amount of valuable time taken in getting and giving the desired information became something of a nuisance. He suggested that even a casual glance should be sufficient to show that the questions were from a committee which was working for this Society and not from a private individual who wished to get some information for some idle purpose. He thought it would be difficult to make the statistics at all complete along certain lines, as the president and members of the faculty are not allowed to give out certain data, and they may not want to say that it is a matter for their board of trustees. Along other lines, such as the space required to properly instruct a student in drawing, in machine-shop practice, etc., or the maximum number of students that can be accommodated, he thought there should be no trouble, but that possibly a commentary might be necessary so as to enable the committee to tabulate the figures intelligently. He expressed his willingness to do his share and give all the time he could, and would appreciate the work done by the committee as he had a great deal of use for such information.

PROFESSOR RANDOLPH suggested that if the questions be sent to the Presidents of the institutions, that

the heads of the engineering departments interested be also notified of the fact.

PROFESSOR HUMPHREYS called attention to the fact that colleges with large equipments and many buildings and instructors might use it as an argument against some smaller institution, when it may be that the former have more floor space than they really need. It is a question as to how much of such statistics boards of trustees would like to have published, and if a professor might not get himself into very serious trouble if he told too much. It seemed to him that the main work of this Society ought to be to coördinate engineering instruction and to give such definitions as Professor Merriman had indicated, and he thought it would be well if the committee would get up proper definitions of the technical terms, "college," "school, "department," and the various other terms that they use.

PROFESSOR E. G. HARRIS predicted that the information concerning the matter of cost would give the most trouble; but that if we could get it, it would be exceedingly interesting, and to some institutions perhaps a little embarrassing, either from the point of view of the student or from the point of view of the legislator, and that some colleges would not like to have it published. Young men would naturally be inclined to go to that institution at which they could get their education most cheaply; and some institutions would tremble if the legislators knew exactly what it cost the state to graduate a student in engineering.

PROFESSOR MAGRUDER replied that for the state insitutions, and for many of the privately endowed ones, the facts from which these data could be obtained are

annually printed in the report of the commissioner of the Bureau of Education.

PROFESSOR WALDO thought that statistics might be quite misleading in one or two particulars. For example, in an institution with a large number of students, their schedule of class hours can be so arranged that a corps of instructors in the machine shop can keep the shop running for 8 to 10 hours a day for every day of the week with class work, then it becomes apparent that under these conditions, a smaller floor space is just as good as a large one, or a large floor space may be used under other conditions. Hence it is a question of how the institution is organized and how it uses its material equipment, as to whether the floor space is adequate or not.

PROFESSOR TALBOT stated that at the University of Illinois, while the new shops were possibly large when first built for the students then enrolled, yet as the entering class in 1900 in engineering doubled the number of students in the previous classes, the shop floor space was no longer excessive. He called attention to the fact that the report of the committee tried to elicit from the members whether they would be willing to take the time and make the effort to get statistics which would be comparatively correct, and so that those of one institution could properly be compared with those of another. He endorsed Professor Merriman's suggestion that any questions which are sent out should carry with them very definite descriptions of what is wanted and complete definitions, so that the answers can be made equally definite and so that the questions will not be misunderstood, either by the one

who answers them, or by the one who reads the report. He also called attention to the fact that certain statistics might be misleading as buildings and land cost less per square foot of floor space in the country than they do in the city.

PROFESSOR GRAY said that the kind of statistics that he wanted was not the number of square feet of floor space that any college possessed per student, but the number of students which could be instructed in a given subject on a given floor space and the cost of that floor space. Such figures would enable others to intelligently plan buildings suitable for an expected number of students. He suggested that heads of departments state how many they could properly accommodate in their shops, laboratories and rooms, and how much these cost. He was of the opinion that it was not necessary to give the name of the college, but to designate each by a letter.

In closing the discussion of the report, PROFESSOR MAGRUDER stated that the committee appreciated the fact that it will take some time of each member to study and correctly answer the questions which will be propounded; but that the committee would prefer that unless the questions are answered with approximate correctness that they be left unanswered, as it would fall to the lot of the committee to defend not only their conclusions, but the premises on which their comparisons were based. The committee therefore asked for the personal coöperation and assistance of every member of the Society to the end that time should not be wasted but that comparative facts should be obtained.

NELSON OLIVER WHITNEY,

Died March 17, 1901.*

Nelson Oliver Whitney was born May 3, 1858, at Aiken, South Carolina, where his parents were temporarily located. He graduated at the Mantua Academy of Philadelphia, in 1874, and from the civil engineering course of the University of Pennsylvania in 1878. During the summer following his graduation he was on the geodetic survey of Pennsylvania, and the next winter he was instructor in civil engineering in the University of Pennsylvania and in the Pennsylvania School of Industrial Art. From 1878 to 1880 he was in the office of the chief engineer of the Pennsylvania Railroad, where he was engaged in construction work. The next two years he spent in Mexico as locating engineer, under the late A. M. Wellington, on the Mexican National Railroad. In 1882 he returned to Pennsylvania and became locating engineer on the South Pennsylvania Railroad, and from 1884 to 1886 he was resident engineer on the Tuscarora tunnel.

In 1886 he was appointed assistant to the chief engineer of the Pennsylvania Railroad in charge of maintenance and construction at Chicago. It was from this position that he was called to the chair of Railroad Engineering at the University of Wisconsin in 1891, which place he filled until his death.

The illness of Professor Whitney dates from November, 1899, when he contracted a severe cold while returning with his class from an inspection trip to Pittsburg. The cold soon developed into a severe attack of pneumonia which was complicated by weakness of the heart, and after an heroic struggle lasting for a year and a half he passed away on March 17, 1901.

Professor Whitney had the practical man's horror of "rushing into print," and although he had a great amount of valuable material derived from his own experience, which he gave his classes, he could never be persuaded to publish it. His disgust was great when, in discussing the merits of some engineer, some one less familiar with the achievements of engineers would raise the query as to what the man had written. With him, a difficult piece of construction successfully carried out, a railroad emergency quickly and skillfully met, or an army of workmen efficiently directed were the things which were to test the real merit of the man.

* Memoir prepared by Professor Frederick E. Turneaure.

Professor Whitney would doubtless have disliked to teach the more elementary subjects, as his methods were adapted rather to mature minds. He believed thoroughly in placing a student on his own responsibility, and, while devoting a large amount of time outside of classes in assisting the students, he always encouraged independent action. A considerable portion of his work was consequently carried on by the seminary method.

As a teacher Professor Whitney was certainly highly successful, and the influence of his high and noble character was strongly felt by all who came in contact with him.

Professor Whitney was a member of the Society for the Promotion of Engineering Education from its organization; he was also a member of the American Society of Civil Engineers, of the Western Society of Engineers, and of several railroad clubs and other societies. He was married in 1883 to Miss Mary Taintor, of Philadelphia, who, with five children, mourns the loss of a model husband and father.

VOLNEY G. BARBOUR,

Died June 4, 1901.*

Professor Barbour was born in Connecticut in June, 1842. He served as volunteer in the 5th Connecticut regiment throughout the Civil War. In 1867 he graduated from the Sheffield Scientific School of Yale University with the degree of Ph.B. In 1887 he received the degree of Civil Engineer. In 1869 he was called to the chair of civil engineering in the University of Vermont, which he filled for thirty-one years, and held at his death. He was special professor of sanitary science in the Medical Department 1886–88. He was superintendent of buildings and grounds of the University from 1873 to the time of his death; city engineer of Burlington for the periods 1871–74 and 1885–86; and school commissioner for the first ward from 1896 to 1900.

For several years he was connected with the United States Coast and Geodetic Survey in that region, and was the civil engineer employed by the commissioners to settle the disputed boundary line between Vermont and Massachusetts in 1896.

He was a valued member of the board of directors of the Mary Fletcher Hospital, and gave much attention to the new buildings and other affairs of that institution. He was also a member of the ex-

*Abstracted from the Burlington *Free Press* of June 27, 1901, by Professor Robert Fletcher.

ecutive committee of the Home for Aged Women, and for many years a trustee of the Y. M. C. A.

Professor Barbour was esteemed as one of the most valuable, as he was one of the most modest and unassuming men in Burlington. He was an admirable teacher and his services to the University as superintendent of buildings and grounds were invaluable. His ability as an engineer made him a recognized authority and a valued adviser, not to the University alone but to the city and to many individual clients.

President Buckham, in an eloquent and touching eulogy, said: "The meaning and worth of Professor Barbour's life consisted mainly in this—that he was a teacher. For thirty-one years past he has served the University as a teacher, and he was a rare teacher. Any institution of learning, however large may be its corps of instructors, is favored of God and deserves the respect of men if it has two or three men who have a genius for teaching. We certainly have had one in Professor Barbour. * * * He set for himself a high standard of attainment in the learning of the profession he served. He kept abreast with the progress of knowledge and of methods in the profession. He was a laborious student himself and was successful in getting hard work out of his pupils. But, more than any man I have ever known he put himself into his teaching. In spite of what I have said as to his being preëminently a teacher, I think of him rather as a man teaching, a whole man teaching. He gave himself, all he was and all he had, of knowledge, of character, of influence, of heart and will to his pupils.

* * * "But Professor Barbour, though mainly a teacher, was not merely a teacher. He was so much a teacher partly because he was something besides a teacher. He was a man of many interests and varied activities. As he carried into his other relations the unworldly spirit and the fine temper of the college man, and thereby dignified his connection with them, so he brought into his college relations something of the breadth and freedom and sagacity of the man of the world. I think we of the faculty would all admit that he was the wisest man among us.

"If I have spoken in terms of admiration of Professor Barbour as a teacher, as a public man and as a citizen, I must still reserve my warmest words of esteem and affection for his personal qualities, for the colleague, the friend, the Christian, the lovable and beloved man." * * *

INDEX.